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H. D. HUTCHINSON, C.S.I.,
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COLONEL A. C. MACDONNELL,
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Specially Designed and Arranged for the use of Officers preparing for Promotion Examinations.

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BY

LT.-GEN. H. D. HUTCHINSON, C.S.I.,

Late Director of Staff Duties.

Author of "Military Sketching Made Easy," "Military Training in English and Hindustani," "Tactics Made Easy," "The Story of Waterloo," "The Story of 1812," &c., &c.

SIXTH EDITION.

FULLY REVISED TO DATE BY

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The Author is very gratified to find that this Book continues in such constant demand as sufficiently to prove that it amply fulfils the purpose for which it was originally written, viz., to assist Officers preparing for their Promotion Examinations in *c* and *d*.

This new edition is carefully revised up to date and *fully illustrated by the addition of thirty new plates*, which must add greatly to its value as a work of reference.

H. D. HUTCHINSON, MAJOR,
Bengal Staff Corps.

ALMORA,
January, 1891.

PREFACE TO THE FOURTH EDITION.

These Notes are still continually asked for, but press of work has long delayed the revision rendered necessary by frequent changes in armaments and conditions. They are now, however, carefully brought up to date, and it is hoped that they will smooth difficulties in the future as they have done in the past. A long experience as an Instructor has convinced me that the subjects are arranged in the order the most convenient for the student.

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Director of Military Education in India.

SIMLA,
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PREFACE TO THE FIFTH EDITION.

These Notes have been entirely revised and brought up to date. Special attention has been paid to the *practical* side of the subject, and the example of a small tactical scheme worked out with limited time and tools, in Chapter XII., will, it is hoped, prove useful both for examination and practical purposes. The examples worked out in the text should clear up most difficulties. The reviser has borne in mind the requirements of the new examinations for promotion, and specially designed these notes to meet them.

May, 1904.

PREFACE TO THE SIXTH EDITION.

These Notes have again been thoroughly revised and brought up to date.

A. C. MACDONNELL, COLONEL (late) R.E.,
Instructor in Military Subjects.

ARMY COLLEGE, HEATHEND, FARNHAM,
February, 1910.

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FIELD FORTIFICATION.

NOTES ON THE TEXT-BOOKS.

CHAPTER I.

ARMS AND PROJECTILES.

A knowledge of the power and nature of the arms employed is essential for an intelligent appreciation of the principles of fortification. Not only do the arms employed modify tactical dispositions, which are paramount in regulating the general disposition of works of defence, but the amount of cover to be provided is entirely a question of their penetration and searching power, while their range and rate of fire has a material influence over the details of works and obstacles required.

The weapons employed by civilised armies may be classed under the following heads:—

(*a*) Rifles.
(*b*) Machine guns and light Q.F. guns.
(*c*) Field guns and light guns of position.
(*d*) Field howitzers.
(*e*) Siege Train.

From the field works point of view there is no great difference between our own weapons and those of other civilised armies, and for practical purposes the properties of the former may be taken as a guide.

THE RIFLE.

The arm of the British Regular infantry is the short Lee-Enfield magazine rifle, Mark I*. The magazine, which is attachable at pleasure, carries *ten* cartridges. The rifle can be used as a single shot rifle

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even when the magazine is attached, there being what is called a "cut off" on the rifle, which prevents the magazine coming into action until required. The rifle is fitted with two sets of sights: one set in the usual positions on the barrel for distances up to 1,800 yards; the other, on the left of the rifle, for extreme ranges up to 2,800 yards, but the weapon will carry fully two miles.

Using the 500 yards sight, if aim be taken at the feet of a man standing at 500 yards or any less distance, he must be hit, since the bullet rises less than 4 feet above the line of sight. If the bayonet be fixed, the trajectory is practically unaltered.

The calibre of the rifle is ·303 inches. Its weight, with an empty magazine, is 8 lbs. 2½ ozs. Its length without bayonet is 3 ft. 8½ ins. Its length with bayonet is 5 ft. 2 ins. The magazine, full, would add about 10 ozs. more. The cartridge for this rifle is made up with cordite, and the muzzle velocity is 2,000 feet per second. Using the magazine, the rate of fire is about 4 seconds per round.

The arm of the Territorial Force Infantry is the Charger Loading Magazine Lee-Enfield Rifle, Mark 1*.

Full information as to the penetrative powers of the rifle is to be found in the service text books.

The most useful thing to remember is that 3 feet to 3 feet 6 inches of ordinary soil is proof against modern rifle bullets. Ramming earth reduces its resisting power, probably because in loose earth the bullet has room to turn round and is not compelled to move point foremost. Earth, however, varies greatly in its resistance to penetration, sand being the best material, and wet clay the worst (requiring a thickness of 5 feet to be proof). In practical work in the field the question presents no difficulty, as the necessary thickness to be given to a parapet to make it proof can always be ascertained by firing at a small type section.

Timber.—It will be observed from the penetration table in Manual of Military Engineering, that timber cannot

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be reckoned on as a practical means of resisting the penetration of modern rifle bullets, the thickness required being too great.

As regards brickwork and stone walls, the necessity of avoiding penetration at the joints will often necessitate a much greater thickness than is required for merely one brick or stone to be proof, *e.g.*, a stone sangar would have to be at least 18 inches thick in order to avoid "through" joints, and a brick wall to be absolutely proof against a shower of bullets for the same reason would require a thickness of 1 foot 2 inches, or a brick and a half.

Shingle, stones, macadam, etc., between boards are eminently suitable for blockhouse walls, defence of windows, etc., as 6 inches only is proof.

The searching power of the rifle at effective ranges is not great, as at 1,000 yards the slope of descent is only 1 in 26, and at 2,000 yards 1 in 10.

TERMS APPLIED TO RANGES.

The following table (taken from F.S.R. Pt. I., 1909) gives the various ranges of the different weapons:—

Terms applied to Ranges.	Rifle.	Field Artillery.	Heavy Artillery.
	Yards	Yards.	Yards.
Distant.....	2,800—2,000	6,500—5,000	10,000—6,500
Long.....	2,000—1.400	5 000—4,000	6.500—5,000
Effective	1,400—600	4,000—2,500	5,000—2,500
Close.....	600 and under.	2,500 and under	2,500 and under.

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HEIGHT OF INFANTRY FIRE.

The heights over which an average man can fire on level ground are:—

Lying down, 1 ft.
Kneeling, 3 ft.
Standing, 4 ft. 3 in. to 4 ft. 6 in.

These heights must be adjusted to suit different men. Down a steep slope these heights may be reduced by as much as 6 ins., and firing uphill a man can fire over a higher parapet.

MACHINE GUNS.

The ·303 Maxim fires the ordinary rifle cartridge. It can deliver bullets at the rate of 600 per minute, or can be used as a single loader.

Its range and penetration are as stated for the rifle.

It might gain in penetration through brick walls by placing a succession of bullets on the same spot.

The carriages for it are the cavalry, infantry and parapet, the latter enabling it to be fixed to an ordinary infantry parapet.

To get the best value out of the gun it must be kept steady on its mounting.

The tripod mounting, suitable for pack transport, consisting of a pivot and crosshead, three legs and traversing and elevating gear, fulfils this requirement very well.

The principal value of machine guns lies in delivering a rapid and sustained fire in a given direction. They are therefore particularly useful for sweeping approaches, or covering certain points, which an enemy in advancing is likely to pass or occupy.

They should always be very carefully concealed from the enemy's artillery fire.

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LIGHT Q.F. GUNS.

The 1 pr. Q.F. Vickers-Maxim, or Pom-pom, is a type of these guns. The shell is too small to be effective as a man-killer, and the effect against cover would be trifling. They are no longer included in our armament.

There is one factor that cannot be neglected, and that is the extremely demoralising effect its rapid rate of fire has on the nerves of the troops exposed to its action in the open.

The 3-pr. quick-firing gun can deliver from 10 to 15 aimed rounds per minute. It is very accurate up to 2,500 yards, and can be worked by two men. It is intended chiefly for fortress defence, and would be very effective against an approach by sap. It cannot travel over a rough country, or at a rapid rate. It fires only common shell.

ARTILLERY PROJECTILES.

Before dealing with the various branches of artillery, it is advisable to know the general characteristics of the ammunition employed in the field.

The only projectile used by Horse and Field Artillery guns in our service is shrapnel shell. Field howitzers and heavy guns use lyddite shell and shrapnel, and occasionally "star shell" for special purposes.

Common Shell.—This is a general term for all shells with either a high explosive or ordinary bursting charge, and is used with a percussion fuze.

The lyddite shell is a high explosive common shell.

Shrapnel Shell is made to carry as many bullets as possible, and is given a burster just sufficient to open the shell and release the bullets. When the shell opens the bullets travel forward, spreading gradually into a cone. The sides of the shell are much thinner than those of common shell, being made only just sufficiently strong to stand the shock of discharge without breaking up. The bursting charge of powder is very small, only about three-quarters of an ounce, just sufficient to break open the

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shell, and liberate the bullets. Thus, the effect produced depends, not on the size of the bursting charge employed, but on the velocity of the projectile at the moment the bullets are set free. Shrapnel shell is burst either with time or percussion fuzes.

Time Shrapnel is essentially a man-killing projectile, its penetration being less than a rifle bullet, but its searching power is considerable, especially when fired from field howitzers, giving a steep angle of descent. The present time fuze is effective up to 6,000 yards.

Percussion Shrapnel.—This is effective for "ranging," or against troops in buildings and behind cover, such as walls and gun shields, but greater accuracy in hitting the target is necessary.

Lyddite Shell is a shell containing as powerful a bursting charge as possible, which, on explosion, breaks up into a large number of splinters. They are effective against material and artificial cover, but, except for the splinters, their effect is very local, though their moral effect is considerable. When burst on the ground they are poor man-killers. Lyddite is the Service high explosive used, and they are exploded with percussion fuzes.

FUZES.

There are four principal classes of fuzes:—

Time Fuzes, which are ignited by the shock or flash of discharge, or by the rotatory motion of the shell, and which are so arranged as to communicate fire to the bursting charge at the expiration of a given interval of time, this interval being regulated before the shell is fired, by boring or setting the fuze.

Percussion Fuzes, which communicate fire to the bursting charge when the shell strikes or grazes.

Time and Percussion Fuzes, which combine the properties of the other two classes. They can be set as time fuzes, and if the time fuze does not act will explode on percussion.

Delay Action Fuzes: Percussion fuzes which allow the shell to penetrate some way in before bursting.

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FIELD GUNS.

Under this head come Horse and Field Artillery, Mountain Batteries, and Divisional Heavy Artillery.

The Horse Artillery are at present armed with the 13-pr. Q.F., and the Field with the 18-pr. Q.F.

Mountain Batteries are armed with the 10-pr. B.L. screw gun. These guns are in two pieces to allow of their being carried on mules, the weight being about 200 lbs. for each mule.

Field guns almost entirely rely on shrapnel shell with time fuze. It is the best man-killer against troops, either in the open or behind cover. The shell is too small to make an effective common shell. Common shell with percussion fuze was formerly carried for ranging, as the cloud of smoke from its burst showed clearly the point of impact of the shell. This has not been considered a sufficient reason for its retention in the British service, though foreign armies still employ a small proportion filled with high explosive.

A *low parapet with flat exterior* slopes will, at effective ranges, throw up most shells in these days of high muzzle velocities, hence the employment of common shell *to breach* parapets is not worth while attempting, as it entails very accurate shooting to hit the parapet, and probably, even if it does strike the parapet, the shell will ricochet harmlessly over. Using common shell with percussion fuze as a man-killer against troops behind cover requires a *crest* hit to be successful, and this would entail a very high degree of accuracy.

Percussion Shrapnel is used for ranging. It can be used against troops behind walls, and the 13 pr. has given excellent results against a brick wall 26 inches thick.

Field Artillery therefore attempt to destroy troops behind cover by *searching* them out with time shrapnel.

The limit of the forward effect of shrapnel at effective range is about 200 yards. If shrapnel is burst in the air some distance before it reaches the trench there is a good chance of some of the bullets finding their way into the trench and striking the defenders.

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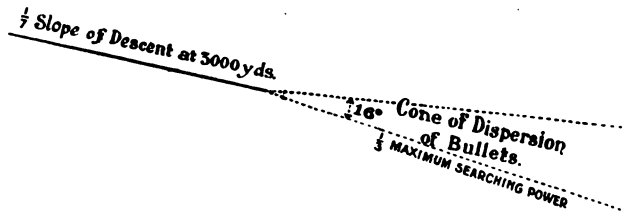
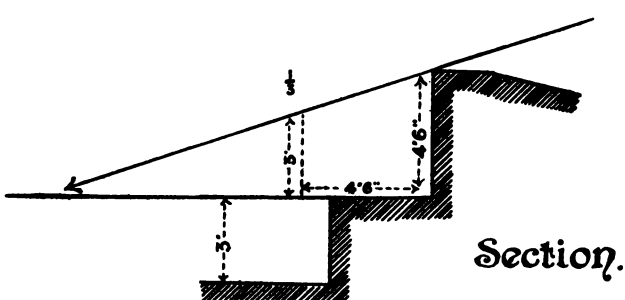
At 3,000 yards the angle of descent from the 18 pr. is about 1 in 7, if you add to this the lower half of the cone formed when the time fuze acts, you get a searching power of about 1 in 3.



It is essential to understand exactly what is meant by this searching effect to appreciate the principles of modern entrenchments. If a parapet is 4 ft. 6 in. high, shrapnel bullets at 1 in 3 would not hit the ground nearer than 13 ft. 6 in. away from the foot of the parapet, *provided the fire was perpendicular to the front of that parapet*, and you would only get 3 ft. of cover 4 ft. 6 in. away from the foot of this parapet. If, therefore, you wished for a man to be able to stand up 4 ft. 6 in. away from the foot of the parapet, you would have to *go down* another 3 ft. Thus:—



Section.

If fire is not perpendicular to the front of the parapet, obviously a bullet at 1 in 3 can strike much nearer to the foot of the parapet than as above.

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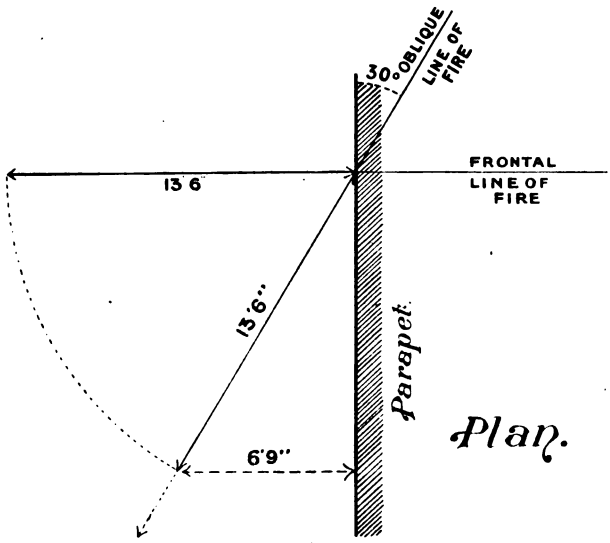

If line of fire made at an angle of, say, 30 deg. with the line of trench, it can be seen from above figure that instead of striking the ground 13 ft. 6 in. from the foot of the parapet, the distance is only 6 ft. 9 in.

B.L. guns fire over a height of 3 ft.; M.L. over 3 ft. 6 in.; and the 2.5in. mountain gun over 2 ft.

RANGES OF ARTILLERY.

In close countries 3,500 yards is as much range as you can hope to get, and ranges are generally limited by the power of *vision*, not by the power of the gun.

It is not essential for the gun to see the target, provided the effect of its fire can be *observed*, hence it will be often possible to get the distant ranges shown in preceding table on page 3 by using the guns for oblique fire.

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Practically with all natures of artillery anything that can *be seen and observed* can be hit or searched, hence the low parapets and flat slopes, in addition to making projectiles ricochet, also provide that essential requirement, *concealment.*

The *minimum* range of guns is generally determined by the fact that, unless under very special circumstances, they will not venture within effective infantry fire.

LIGHT POSITION GUNS.

These guns, of which our 4.7 in. Q.F. is a type, are not much more effective against earthworks than field guns. Their range is longer, and their shrapnel bullets are heavier, but their searching power is little greater, and their shell can equally be deflected, even if the percussion fuze is not set in action, by a very slight bank of earth. Their common shell have little breaching power against an earth parapet, provided that the command is low and the exterior slopes are flat.

The best means of employing guns against trenches and other earthworks is to utilise their long range for oblique fire, and thus to increase their searching effect.

The 4·7 in. on travelling carriage has the axis of the gun 3 ft. 8 in. above the ground, and on the converted travelling carriage 4 ft. 5 in.

In India the 30 pr. B.L. gun is used.

FIELD HOWITZERS.

The field howitzer is one of the modern weapons that has wrought the most important changes in fortification. The British field howitzer is the 5 in. B.L., and in India the 5.4 in. B.L.

Firing at high angles of elevation, they possess great searching power, and, further, can be concealed behind reverse slopes, woods, etc., over which they can fire without being seen.

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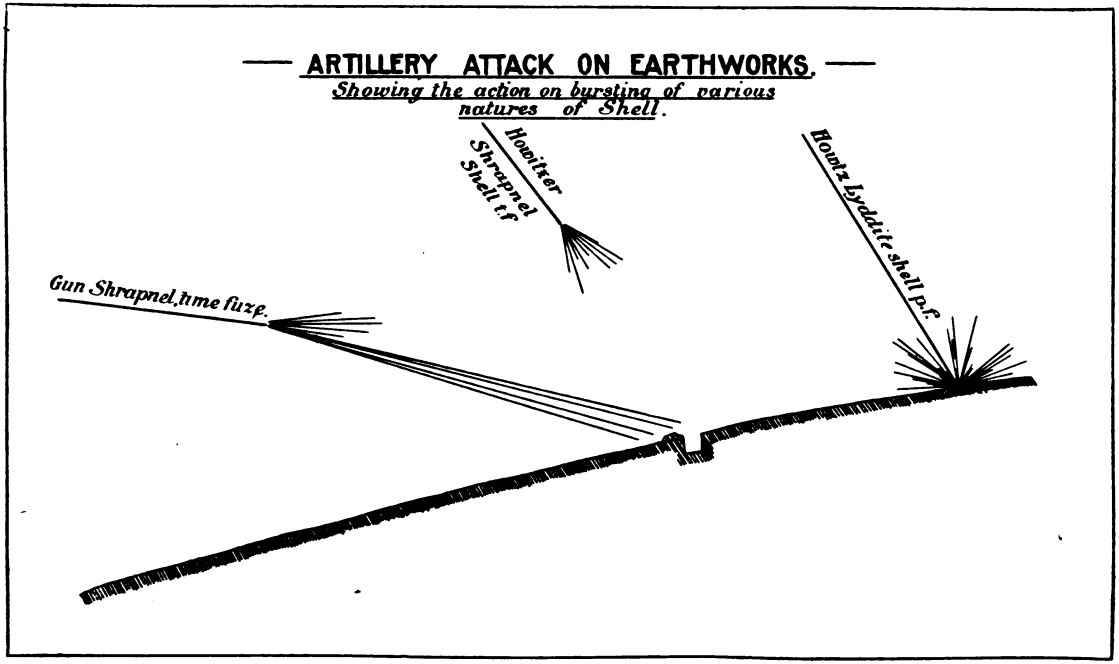
ARTILLERY ATTACK ON EARTHWORKS.
Showing the action on bursting of various natures of Shell.
Howitzer Shrapnel Shell t.f
Gun Shrapnel, time fuze.
Hount z lyddite shell p.f.

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The projectiles are shrapnel and lyddite shell.

Howitzer shrapnel is now used by most nations. The searching power is naturally very great.

The searching power may considerably exceed 1 in 1, but on the other hand the fire will have to be very much more accurate than in the case of field gun shrapnel, as the area covered is more limited. (See Plate I.)

Cover from these bullets is best got by providing overhead cover in some form.

Common Shell might be used with percussion fuze or delay action fuze. In demolishing cover a very much enhanced effect is got if penetration is effected before burst, the earth helping to tamp the shell. The 5 in. shell weighs 50 lbs. and contains nearly 10 lbs. lyddite.

No amount of cover you can *extemporize* in field works will resist howitzer common shell. The only thing that can be done is to *confine* the burst, which is very local.

Twelve inches of earth will give protection from splinters.

The radius of action of a howitzer common shell is about 25 yards.

The splinters of common shell from guns and howitzers at low angles of elevation all go *forward*.

It is important to have nothing behind a work that will catch shells and *make* them burst back. If any cover is put up with a view to protection against back burst it should be just thick enough to resist splinters, and thin enough to allow the shell to pass through it without any chance of being detonated.

The only shells that burst back are howitzers fired at a high angle of elevation.

Whether the ground is hard or soft has an important bearing on back burst, as soft ground may smother the shell.

As howitzers are entirely dependent on good *observation* for an effective fire, what has already been said about *concealment* is still more emphasised. Concealment is almost, if not quite, as important as the cover itself.

The different natures of fire from field guns and howitzers are shown on Plate I.

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TABLE SHOWING ORGANISATION OF THE ARTILLERY OF THE FIELD ARMY.

	Number in	
	A Cavalry Division.	A Division.
Horse Artillery Batteries	4	—
Horse Artillery Brigade Ammunition Columns ...	2	—
Field Artillery Batteries	—	9
Field Artillery Brigade Ammunition Columns ...	—	3
Howitzer Batteries	—	3
Howitzer Brigade Ammunition Columns	—	1
Heavy Batteries	—	1
Heavy Batteries Ammunition Column	—	1
Divisional Ammunition Column	—	1

Natures of Artillery Fire.

(*a*) *Direct Laying* at a visible object, from the gun sights.

(*b*) *Indirect Laying*, at objects not necessarily visible, from the gun sights.

(*c*) *High-angle fire*, from guns, howitzers, and mortars, at angles of elevation exceeding 25 degrees.

With reference to the horizontal.

(*a*) *Frontal Fire.*—When the line of fire is perpendicular to the front of the target.

(*b*) *Oblique Fire.*—When the line of fire is inclined to the front of the target.

(*c*) *Enfilade Fire.*—When the line of fire is along (or nearly so) the front of the target.

(*d*) *Reverse Fire.*—When the rear instead of the front of the target is fired at.

Note.—When the projectile sweeps the surface of the ground, the fire is called *grazing*. This is a most effective description of fire. When much depression is required,

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or the visible object is much below the gun, the fire is called *plunging*. This is the least effective kind of fire. *Flanking fire* is the fire of the defence, designed to protect some distant part of their line, by taking in flank the enemy who are attacking it. It must not be confounded with *enfilade* fire, which is the fire of the attack, designed to rake the defender's lines, or entrenchments.

SIEGE TRAIN.

Under this head come the weapons that would have to be brought up to supplement the field army weapons in the event of an attack on a modern fortress, or perhaps a very carefully prepared position.

It will largely consist of howitzers, both on account of their effectiveness in demolishing cover and principally the ease with which they can be concealed. The 6 in. B.L. howitzer of 30 cwt. (India 25 cwt.) is a type of a medium siege howitzer.

In the event of armoured defences having to be demolished, a certain proportion of direct firing guns will be necessary. They will need very careful masking if used. The 6 in. B.L. is a type of such a piece. In any case guns are sure to be useful, as howitzers are not very effective against *moving* bodies of troops.

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CHAPTER II.

GENERAL PRINCIPLES OF HASTY ENTRENCHMENTS.

The main object of fortification is to enable a Commander to economise that portion of his force allotted to "Defence" in order to increase that available for offensive action by which alone decisive results can be obtained.

By "Field Defences" we mean those works and arrangements which could be undertaken by an army in the field on the eve of battle, or in expectation of being shortly attacked. Their extent and character would be determined by the configuration of the ground, the time and means available, the proposed character of the defence, *i.e.*, whether it is to be an active or a passive defence, and similar considerations. But whatever fortification is undertaken, five principles must always be kept in mind:—

(1) The positions to be defended must be chosen with due regard to tactical requirements.

(2) The attacking troops should be exposed as much as possible to the fire of the defence during the advance. This may involve the clearing of the foreground.

(3) The troops of the defence should be sheltered behind cover sufficient to resist the fire of the attack, or at least to afford concealment. This cover should be so arranged as to permit the greatest possible development of the fire of the defence delivered under the most favourable conditions.

(4) The free movement of the attacking troops should be limited, as far as possible, by leaving or creating obstacles intended to detain them under fire, or interfere with their tactical dispositions.

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(5) Full freedom of movements should be secured for the defence to reinforce threatened points, or to deliver counter-attacks.

Shortly stated these principles are:—

1. Choice of ground.
2. Clearance of foreground.
3. Provision of cover.
4. Creation of obstacles.
5. Improvement of communications.

Often 2 and 4 would proceed together.

The points above are given in order of importance. In these days of low command parapets, the parapet itself is no obstacle, and the rifle itself is the real stopping power, hence a *field of fire* for the rifle is the first consideration after tactics have been considered. Under *cover* comes *concealment*, which is almost as important as the actual cover.

A defence may be either *active* or *passive*.

An active defence implies that you are strong enough, and intend to attack the enemy yourself in turn, but you choose first to expose him to the loss and demoralisation consequent upon his assailing you in your chosen and fortified position. In this case, besides fire effect, freedom of movement for yourself, as represented by perfect communications, is most essential.

A passive defence is resorted to when you are admittedly inferior to your opponent, and have no hope or intention of attempting a counter-attack. Your only object is to stave off his attack, or to gain time, etc. In this case, besides fire-effect, difficulty of movement for the enemy, as represented by a formidable arrangement of obstacles, is the most important consideration.

Napoleon has said that "Field fortifications are always useful, never harmful, *when they are properly understood.*" It is therefore essential that the works undertaken shall be in accordance, and in harmony, with the tactical requirements and conditions of the situation; and it must always be remembered that as the effect of judicious fortification is to economise the defensive force available, so the force thus reserved should be applied ultimately for *offensive* movements by which alone de-

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cisive results can be obtained. Under ordinary conditions the possibility of *assuming the offensive* should never be abandoned by the defender, and all works of defence should be designed with a view to this contingency.

Entrenchments are generally considered from the point of view of the defence, but it should be remembered that in the attack any slight cover that can be held by day may be improved by night, and serve as a point for further advance.

The front of a position is usually divided into sections of defence, each of which should if possible be assigned to a distinct unit.

The infantry defending any frontage are usually distributed in three bodies:—

(i) *Firing line.*

(ii) *Supports.* In exceptional cases they may be dispensed with (see F.S. Reg., part I., chap. vii., 108 (8)).

(iii) *Local reserves* to reinforce the firing line and clear the front by local counter attacks.

In addition to these there is the *General reserve*, which has nothing to do with the immediate defence of the entrenchments, and is reserved for the decisive counter-attack.

In order to assist one in looking out for, or taking up, an ordinary position in a general line of defence, it is necessary to realise a *typical* distribution for say half a battalion, which is a unit sufficiently large to provide all the three lines, viz., firing line, supports, and local reserve.

Plate II. shows this typical distribution, from which it will be observed that whatever companies furnish the firing line they must invariably furnish the supports also.

It is usual to keep the men in each section together as much as possible with an average frontage of one yard per man, and intervals are left or not as is found desirable between the sections or larger units, provided the intervening ground in front has effective rifle fire brought to bear on it. This gives great elasticity or adaptability for each half battalion when allotted a frontage for defence. Any position can thus be quickly occupied by a line of half battalions.

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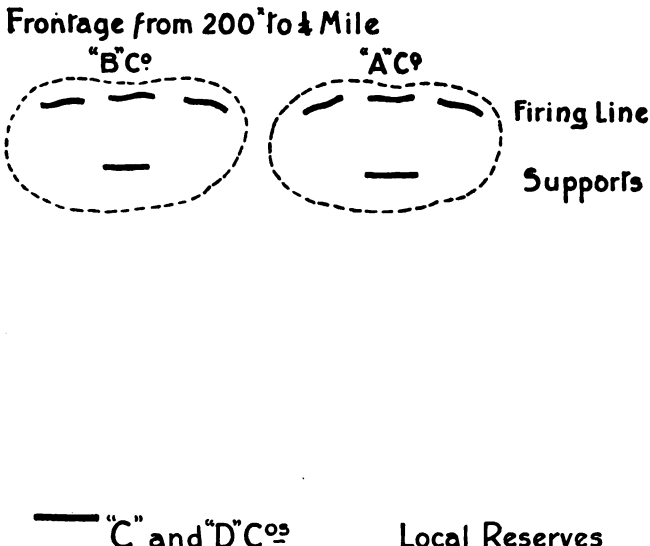
"A HALF BATTALION"

Typical Tactical Distribution in a General Defensive Position



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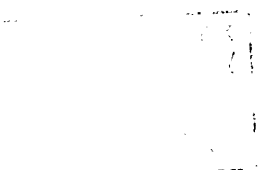

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CLASSES OF ENTRENCHMENTS.

Entrenchments may be classed under two heads:—

(i) Trenches.

(ii) Redoubts. (See Chapter XI.)

Trenches may be further subdivided into:—

(i) Fire trenches for the firing line.

(ii) Cover trenches merely to cover troops not actually engaged.

Generally speaking reserves should in most cases find *natural* cover, if not from fire, at least from view.

In all entrenchments save as much labour and time as you can by making the fullest use of natural cover.

ARRANGEMENT OF TRENCHES.

In any position the field of fire will vary considerably, and it is a matter requiring great practical experience to suitably dispose trenches to the best effect. Some parts of the position will have a fine open field of fire, and will not require so many trenches or obstacles as the closer portions of the country. The great point to remember is that every rifle saved for the reserve justifies the employment of fortification.

Time and tools are limited, and only the most necessary work can be undertaken in the field, hence it is undesirable to consider anything but *one main line of defence*. Trenches are made to be held, and any theory of retiring from one line to another is radically bad, while, even if the second line contained separate troops, their moral would not be improved by seeing retreating troops.

An exception may be made in the cases where it is intended to deceive the enemy as to the main line of defence, or when the main line is at the foot of a slope, and the volume of fire is added to by troops higher up the hill, there being no doubt whatever as to what is the *main* line.

Trenches will therefore be arranged in irregular lines, mainly for frontal fire as may be best suited to the

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ground, but the general arrangement should be as simple as possible with one main line of defence only.

The defenders must understand clearly which is the main line of defence, and successive lines are always to be avoided.

When the ground permits intervals may be left between groups of trenches, and such intervals swept by fire from the flank trenches of the groups. These flank trenches, to fulfil this purpose, must be thrown back out of the general line, and great care will have to be exercised in tracing them on account of their liability to be enfiladed. If liability to enfilade cannot be avoided, special protection against such fire must be given.

In arranging groups of trenches it is necessary to consider what form of offensive action is contemplated by the defenders in various parts of the field. No modern form of shelter trench, without obstacles, will seriously impede infantry, but they may stop cavalry and artillery.

The trace of trenches should, within certain limits, follow the contours of the ground. There is no necessity whatever for straight lines.

CHOICE OF FIRE POSITION.

Trenches or guns on the sky line afford so excellent a target that such a position, especially if the enemy has good artillery, should be avoided. In choosing the best fire position there will generally be a compromise between fire effect, concealment and facilities for communication. The question is one of give and take, and requires much practical experience out of doors.

Slopes may be classed as convex, concave or glacis slopes.

With a *convex* slope (see Fig. 1, Plate III.) if you can get a reasonable field of fire at the foot A *concealment* can be easily obtained, and fire is grazing, but on the other hand *communications* are difficult. At the *military crest* B the field of fire is good, and communications are easier, but on the other hand in many cases the trench will still be on a sky line. At the summit C you have a

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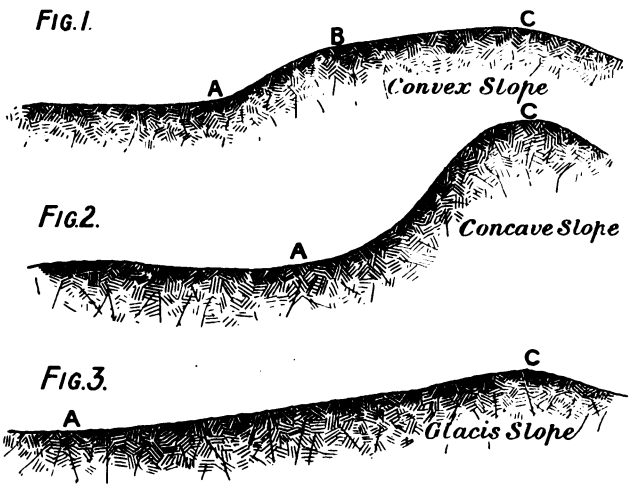
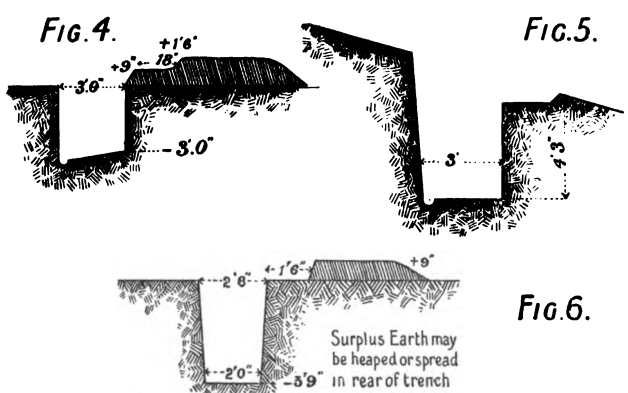
CHOICE OF FIRE POSITION.



FIRE TRENCHES.



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limited field of fire and are on a sky line, but communications are easy.

With the conditions above the foot of the slope would probably be the best position.

Concave slopes (Fig. 2, Plate III.).—A is under the same conditions as in the convex slope. C, the summit, has a good field of fire, but is on a sky line. As the upper parts of the slope will usually be very steep, the defender will be much exposed in firing down hill to the enemy's artillery fire, and to fire from his infantry specially posted to cover his attack.

Glacis slopes (Fig. 3, Plate III.).—This differs from the preceding in the fact that it will be possible to get much more grazing fire down the slope than in the previous cases. Possibly far enough down the hill not to risk a sky line would be the best position.

The position at the foot of the hill has the great advantage that it will be very difficult and often impossible to see the trenches from the enemy's artillery position; and also that his artillery must cease while the attack is at a greater distance from the trenches than if they were on the hill side.

If the ground at the foot of the hill is broken so that the attack can get cover in advancing, a commanding position for the firing line is imperative.

CONCEALMENT OF TRENCHES.

Concealment is even of more value than the material protection afforded by trenches. If a trench is clearly visible to the enemy it may, however well made, be found out by an occasional howitzer shell; and it will certainly be subjected to an accurate fire of shrapnel. This shrapnel fire should do little or no damage to troops in good trenches, but it must have a certain moral effect on them, and will tend to keep them under cover while the attacking infantry approaches perhaps dangerously close.

On the other hand, if the trenches are concealed, the enemy's artillery fire may never come near them at all.

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A purposeless bombardment of this kind will have a good moral effect on the defence, and a bad one on the attack.

The effect of surprise, when the defenders' fire is suddenly opened from trenches, whose existence was unsuspected, is most important.

Concealment is gained in various ways:—

(i) By *position*. As has already been pointed out, *a sky line* is to be avoided. A distant background also tends to make a trench conspicuous.

If by any chance a position that entails these disadvantages is enforced, some sort of screen to form a background should, if time permits, be improvised.

(ii) *By keeping the command as low as possible compatible with a clear field of fire over the ground in front.*

By *command* is meant the height of the top of the parapet above the natural ground.

Every foot the command is increased beyond what is necessary helps to make the work harder to conceal, and aids the enemy to discover that such a work exists.

In fixing the necessary command for a trench remember that a clear field of fire is the first essential. You should bend down and view the foreground with your eye at about the same level as the crest of the trench will be. An exaggerated idea of the field of fire obtainable is got from merely looking at it standing, as standing up your eye represents a command of about 5 ft. 6 in. With low parapets a trench wants very careful siting, as when the eye is close to the ground very small bumps or hollows will spoil the field of fire.

Plate III., Figs. 4, 5, 6, give examples of trenches with 1 ft. 6 in. command, no command, and 9 in. command respectively.

(iii) *By making the parapet as much like the ground round it as possible.*

Anything that casts a shadow tends to give the trench away, hence avoid all sharp angles in trace and steep slopes. The ends of a parapet may well be gradually worked off to the natural ground by making the parapet longer than the trench. Nothing in many localities

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could be more conspicuous than freshly turned earth, hence the parapet will often have to be sodded, covered with bracken, boughs, etc.

It is important not to *overdo* concealment, and unless the trench is properly viewed, this is very apt to occur. The trench is being concealed, mainly with the object of deceiving the enemy's *artillery* as to its position, hence the proper place to view it from is the probable artillery position of the enemy. It is remarkable how little judicious concealment will achieve this result. Of course, if time permits, more elaborate measures may be taken, but generally there is little enough time to carry out even essential measures, and the elaboration may do more harm than good. Occasionally it happens that trenches, inconspicuous by themselves, are often rendered extremely visible through the wrong measures taken to conceal them. A sky line is most deceptive when viewed from fairly near the trench, and very often most erroneous conclusions are arrived at, particularly on rounded hills. If the trench is viewed from the enemy's probable artillery position with a good glass and found to be well concealed, all that is required has been done. If possible this should be done before and after the construction of the trench. If time or circumstances do not allow going out so far to the front as the artillery position, it will generally be possible to get out to the limit of effective infantry fire.

Plate IV., Fig. 1, shows an example of a trench excavated in chalk on a steep hill side, covered with grass, and is exceedingly instructive.

(i) Although the ground in front could be seen with no command, it would be impossible to conceal the chalk if it was scattered about the grassy hill sides, as in Fig. 5, Plate III., hence a small parapet actually helps to conceal the trench in this case. Such a parapet would have to be sodded all over.

(ii) The back of the trench might still be visible, and show as a white ribbon on the green hill side. This also would have to be carefully sodded. It

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is obvious that a very erroneous impression of how this trench would look viewed from the opposite hill side is obtained from the foot of the slope.

Dummy trenches are a very useful method of drawing the enemy's fire. Care must be taken in siting them to keep them far enough away from real trenches to avoid the possibility of fire directed against the dummy trenches being effective against the real trench. In Plate IV., Fig. 1, the sods obtained from the dummy trench will come in very useful for the real trench. In a case like this it is obvious that concealing the trench is quite as much work as excavating it, and if time pressed the cover given would have to be reduced and trench made smaller, rather than have a deep trench marked out by a broad white ribbon on a green slope.

LENGTH OF TRENCHES.

Generally speaking allow one yard per man, in addition to space taken up by traverses.

In ordinary cases it is advisable to make trenches to accommodate sufficient men to be under the command of at least one officer, taking a section trench as a minimum.

In providing cover for outposts and skirmishers short lengths of fire trench for two or more men may often be made and form rifle pits.

In providing trenches, if time permits and tools and labour are available, more trenches may be made than are actually necessary for the firing line only. These can be occupied by reinforcements if deemed necessary to increase the fire.

NECESSARY DIMENSIONS OF TRENCHES.

Having sited the trench, determined on the command necessary, and settled its garrison in accordance with the foregoing principles, it only remains to determine its section.

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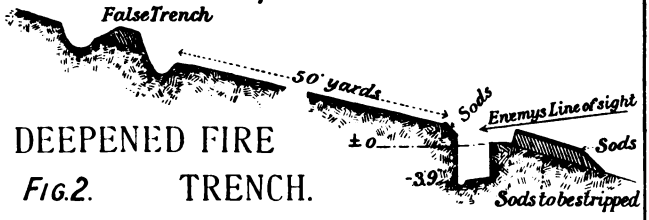
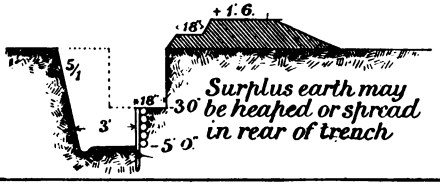
FIG 1 FIRE TRENCH ON CHALK DOWN.

Example of Methods of concealment



DEEPENED FIRE TRENCH.

FIG. 2.



MACHINE GUN ENTRENCHMENTS.

Section

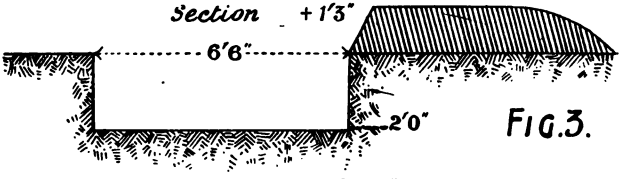
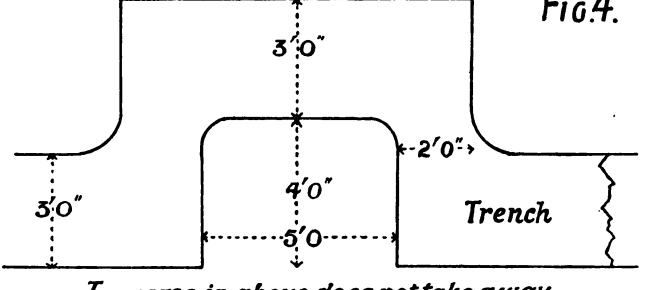


FIG. 3.

FIRE TRENCH WITH TRAVERSE.

Enemys Side

FIG. 4.



Traverse in above does not take away from front of fire

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(i) *Thickness of Parapet.*—Since it is assumed that time shell are only to be taken account of after burst, and the action of percussion shell is not affected by the thickness of the parapet, while the small bore bullet has a greater penetrative power than either shrapnel balls or shell splinters, the measure of *penetration of the rifle* may be taken as that of the thickness of the parapet. Three feet of earth will usually suffice, 3 ft. 6 in. allows for degradation, and 4 feet is necessary to give a good base for loopholes. The parapet must be bullet proof whatever material is used.

(ii) As artillery fire depends on its searching effect, a man must get as *close* to his *parapet as possible*, hence the *interior slope of the parapet must be kept as steep as possible.*

Excavated earth will only stand at 1 in 1, but by using lumps, sods, etc., it may be made to stand at 2 in 1, up to about 5 ft., and 3 in 1 if great care is exercised up to about 4 ft. If any steeper slope is required recourse must be had to regular revetments (see Chapter IV.).

It is essential to have this slope as steep as you can get it with the means at your disposal.

Parapets with interior slope of 1 in 1 would be most uncomfortable to fire over, apart from the poor protection given by this slope.

The front of the trench which is dug out of the natural ground will in most soils stand at the vertical. The necessity for a steep interior slope is another practical reason against increasing the command more than is absolutely necessary to see the ground in front.

(iii) The bottom of the trench should be 3 ft. wide, which allows for free circulation in the trench and enables men to sit down with their backs to the parapet.

If there is a step as in Fig. 2, Plate IV., it should be at least 2 ft. 6 in. wide if *unrevetted.* If revetted 1 ft. 6 in. will suffice.

It is possible to dig a trench 2 ft. wide, being the least width a man can dig, but this is inconvenient. Depth is more important than width, however.

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(iv) The types of trenches shown in the text books are invariably for the standing position. This, of course, gives a man the greatest cover from searching effect. It may be that time does not permit of making this amount of cover, in which case trenches for fire kneeling may be adopted, but the type shown in Fig. 6, Plate III., is recommended when time is very limited.

(v) If a trench is exposed to oblique or enfilade fire the interior must be protected. This can be done by traverses, recesses or overhead cover (see Chapter III.).

(vi) Although parapets are drawn in straight lines in the type sections, as has already been pointed out, anything like sharp intersections of slopes as viewed by the enemy must be studiously avoided for the purposes of concealment.

The exterior slope will not stand at a greater inclination than 1 in 1, and it is desirable to make it as flat as the earth dug out of the trench will allow. The advantages of flat slopes have already been discussed in Chapter I.

An *elbow rest* 1 ft. 6 in. wide and on the average 9 in. below top of parapet is very desirable, as it greatly improves the shooting of the defenders, and enables them to get closer to the parapet.

Downhill the elbow rest will be less than 9 in. below the top of parapet, and uphill more than 9 in.

The top of the parapet will have in the case of steep ground to be sloped off to admit of such ground being seen; generally it may be horizontal.

Do not ram the parapet earth (see Page 2)

Briefly summed up the essential points in a fire trench are:—

(i) Top of parapet bullet proof.
(ii) Steep interior slope.
(iii) Wide enough to sit in.
(iv) Protection from enfilade or oblique fire, and
(v) INVISIBILITY.

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As time admits trenches may be improved by deepening and widening in rear. The trench in Fig. 2, Plate IV., is an example of Fig. 4, Plate III., improved in this way.

Men can sit on the step and facilities of communication are much improved.

For other improvements see next Chapter.

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CHAPTER III.

DETAILS OF TRENCHES.

Traverses are generally an *essential* of modern fire trenches. The advantages of traversing a trench are as follows:—

(i) If a *common* shell does happen to fall in a traversed trench, the effect of its splinters is confined to the space between a pair of traverses.

(ii) It gives protection from the oblique fire of shrapnel and rifle bullets.

To *localize bursts* a foot of earth would suffice, but 3 ft. or 3 ft. 6 in. is required to keep out rifle bullets. Taking the traverse shown on Plate V., which is 4 ft. 6ins. above the bottom of the trench (if the third stage is omitted), it is obvious that if enfilade *rifle fire* only was feared, few traverses would suffice on account of the small searching power of the rifle, but field gun shrapnel of 1 in 3 would strike the bottom of the trench (supposing the trench to be enfiladed) 13 ft. 6 ins. from the bottom of the traverse and howitzer shrapnel might strike the bottom at even 6 ft. from the traverse. Hence, if enfilade or very oblique fire is feared, traverses are not enough. Plate V. shows how this difficulty is met by burrowing into the parapet and forming small *recesses* for one man each and provided with overhead cover constructed in three stages.

If overhead cover is not required, the third stage may be omitted, in which case the height of the traverses will be 1 ft. 6 ins.

Traversing a trench is generally done by leaving a tongue of solid earth at intervals across the trench, and making a communication round it. Recesses are best added when the simple traversed trench is complete.

The way to make the traversed and recessed trench on Plate V. is:—

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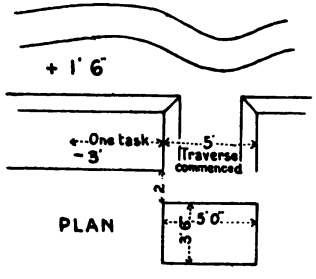
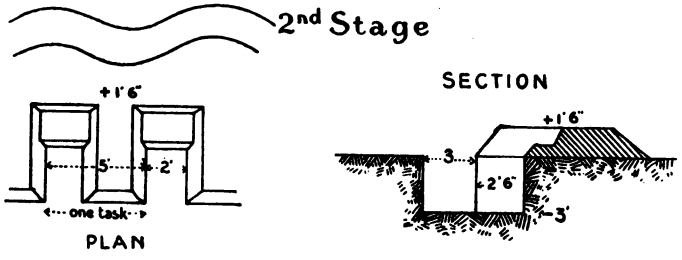
FIRE TRENCH

Traversed, Recessed and with Overhead Cover

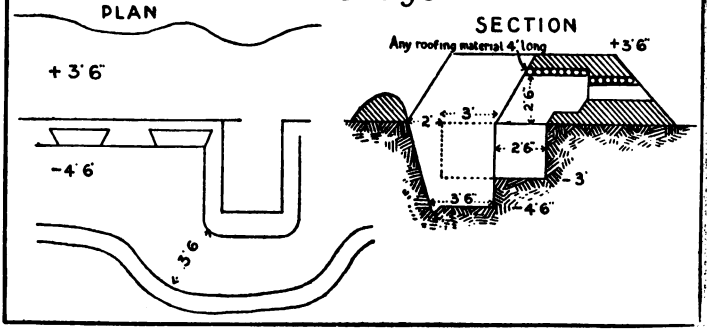
1st Stage



2nd Stage



3rd Stage



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(i) Settle on the tasks the diggers have to do, and at the intervals you want to have traverses (20 ft. to 30 ft. is convenient) leave out a task of 5 ft. This leaves a solid tongue of earth across the trench, which when piled up with excavated earth to a height of 1 ft. 6 ins. forms the traverse.

(ii) Allot two men per traverse to dig out the communication round this tongue of earth and to complete the traverse.

If the third stage on Plate V. is to be omitted this trench may be reduced to 2 ft. wide and 3 ft. deep.

(iii) When the trench is excavated, make the recesses.

In settling the intervals between traverses, you must also consider how the recesses will fit in—about 5 ft. between each recess is necessary. It will be seen that in this type of trench the number of rifles is not one man per yard, but depends on how the recesses fit in.

5 ft. is wide enough for the traverses, as for the first 3 ft. in height they consist of *undug* earth, and 5 ft. will give a thickness of 2 ft. at the top without entailing deliberate revetments.

If the trench is of more command than 1 ft. 6 ins., the thickness at the base of traverses will have to be increased, or recourse had to deliberate revetments.

The best way in this case is to build bullet-proof walls of brushwood and earth across the trench. If brushwood is not available corrugated iron, canvas or some other suitable material between stakes is just as good. This can be done to a plain *untraversed* trench if traverses are found desirable afterwards.

The completed trench, if arranged without overhead cover, when finished, should not have a castellated appearance, due to the extra height in the traverses, etc. This can easily be arranged for by planting twigs, ferns, etc., in the low parts. The extra height may sometimes be undesirable, as discussed below under head cover—in which case the whole crest can be kept at plus 1 ft. 6 ins.

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Recessing parapets of more command than 1 ft. 6 ins. requires skill in revetting.

Plate IV., Fig. 4, shows a method of traversing a fire trench by which the traverses do not take way from the front of fire.

HEAD COVER.

Head Cover is undoubtedly advantageous for protection, but it has some disadvantages, viz.:—

(i) It makes a trench harder to conceal.

(ii) It cramps the field of fire.

The question of providing head cover is a somewhat open one if a trench is made more conspicuous by it and subjected to artillery fire; but there is no doubt that when the enemy can, owing to the ground, come fairly close to the trenches, head cover is an advantage.

Rough head cover may be given by merely notching the top of the parapet (Figs. 2 and 3, Plate Va.).

Loopholes may be made of various materials: sods, sandbags, sacks, biscuit tins, etc.

The shape of a loophole depends on many factors.

(i) The *nature of the material.*—Anything that a bullet will ricochet off must have the narrow opening outside.

(ii) Broad opening outside makes the loophole more conspicuous, but on the other hand makes it much easier to fire out of.

(iii) The *height* of the loophole is entirely governed by the range required—8ins. allows the backsight to be used, but would not be required if only a small field of fire was obtainable.

(iv) The splay required is entirely governed by the extent of ground a loophole has to cover. The narrowest part must take the rifle comfortably, say 3 ins. to 6 ins. A compromise between the small opening inside or outside is to be seen in Fig. 6, Plate Va., which admits of the same field of view as the loophole in Figs. 4 and 5.

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HEAD COVER.

Fig. 1.
Loopholes of Sods.

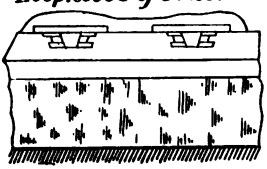


Fig. 2.
Notched Parapets
notches revetted with sods

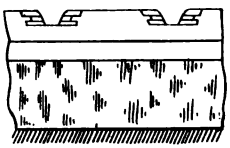


Fig. 3.
Notched Parapets

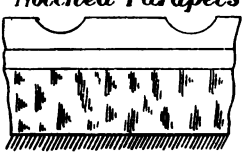


Fig. 4

SANDBAG LOOPHOLE

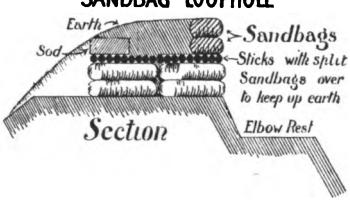
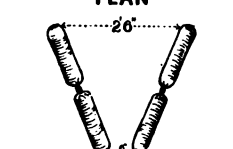


Fig. 5.

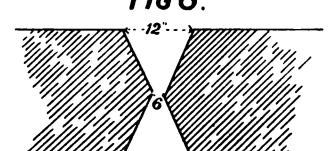
PLAN



3'6" minimum width
from centre to centre
Elbow rest

Sandbags
8 in two lower tiers
2 above
1 split
11 Total

Fig 6.



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OVERHEAD COVER.

FIG. 1 *Lookout with overhead cover*

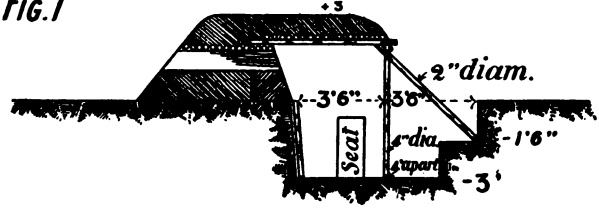


FIG. 2 *Cover combined with Parapet*

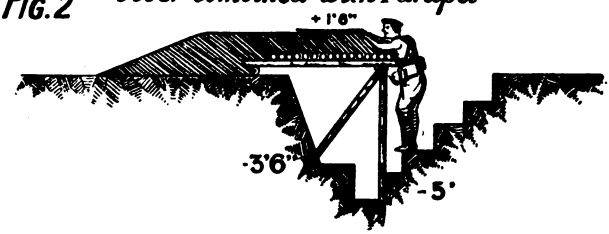
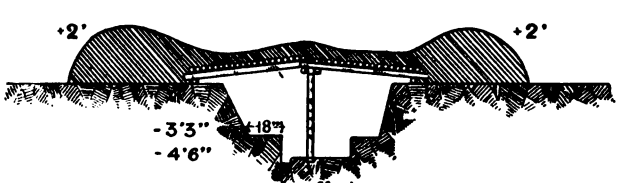


FIG. 3 *Cover Trench communicating with Fire Trench*

FIG. 4

Cover Trench with overhead cover



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A continuous horizontal slit is a common form of loophole, and gives a wide range of fire.

(v) The bottom of the loophole may have to be graded off on falling ground, so that ground in front can be seen.

The best way to make sure loopholes are good is to test them by placing a rifle in them, and thus being certain that the ground in front can be seen.

Fig. 1, Plate Va., shows a sod loophole, the depressions in Fig. 2 being roofed over, and the top earth supported on brushwood.

Figs. 4 and 5 show an elaborate sandbag loophole, eight *headers* and two *stretchers* being required to make the loophole bullet-proof. This would require many sandbags if used in any numbers.

If *bullet-proof* protection cannot be got with the time, labour, etc., available, a *screen* for the head is often better than nothing. A header sandbag will keep out rifle bullets at most ranges, in which case a simpler sandbag loophole than Figs. 4 and 5, Plate Va., can easily be adopted.

Loopholes not in use must be masked with sacks, branches, etc. Loopholes cannot be closer than 3 ft. apart, as a man wants room to use his rifle.

To make *bullet-proof* loopholes requires a parapet 4 ft. thick at the top.

LOOK OUTS.

While the artillery bombardment is going on, the defenders of the trench may be forced to remain sitting with their backs to the parapet. To know what is happening, look out men must be posted.

Plate VI., Fig. 1, shows a covered look-out, which must be carefully concealed. When loopholes are made, a good loophole will do, or, better still, a loopholed *recess*.

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OVERHEAD COVER.

If time, etc., permit of making it, overhead cover gives better protection against shrapnel, and especially howitzer shrapnel, than traverses or recesses.

It generally consists of a roof of earth, supported on brushwood, corrugated iron, or any other material handy.

Planks, if used, must be cut up into short lengths. 12 ins. of earth is necessary to keep out howitzer shrapnel. Probably 6 ins. to 9 ins. will keep out field gun shrapnel.

Overhead cover requires a lot of material if brushwood is used, *e.g.*, Fig 3, Plate VI., requires about two 50lb. bundles of brushwood per foot of cover. For this reason the overhead cover arrangement on Plate V. has many advantages.

Each recess is easily roofed over, and short and light material, such as brushwood, planks, etc., can be made available.

Fig. 3, Plate VI., shows a covered type of trench, into which the firing line might retire till required, or in which supports might be kept.

Fig. 4 shows a broad shelter, with a central upright, suitable for two rows of men.

Fig. 2 shows a fire trench, with overhead cover. It is possible that if the accuracy of artillery increases to such a degree that fire on trenches can be maintained till the attacking infantry are *quite close*, some form of overhead cover, *under* which a man can fire will become imperative. The protected look-out in Fig. 1, if fitted with an elbow rest, would form a type for such a trench.

As already pointed out, nothing will keep out a howitzer common shell if it falls on the right spot.

Splinter-proof partitions at intervals of 10 ft. or 12 ft., consisting of 12-in. walls of earth between brushwood, canvas, etc., should be provided to localize any shell bursting in the cover.

Slight overhead cover, such as planks, corrugated iron, etc., sloping down at an angle of about 15 degrees to the rear, to induce bullets to ricochet, is better than nothing, and will in any case give some shelter from the weather.

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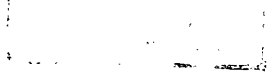

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FIG.1. COVER TRENCHES.

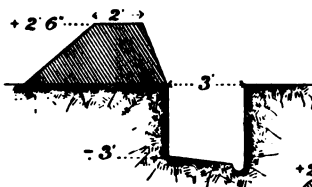
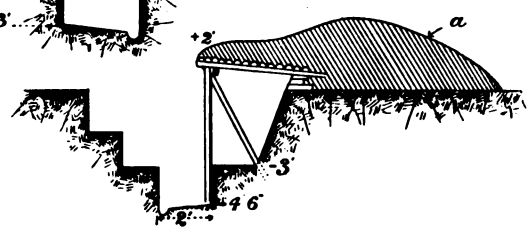


FIG.2.



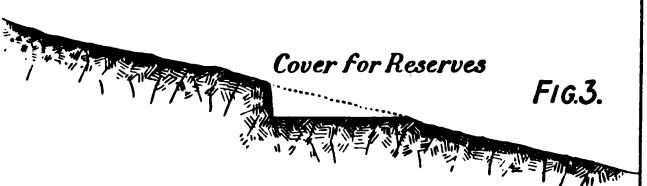


FIG.3.

FIG.4.

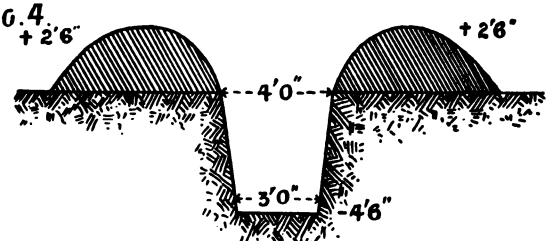


FIG.5. Cover for Artillery.

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COVER TRENCHES.

The firing line may have to withdraw from the fire trenches during bombardment, or troops not actually engaged may require artificial cover.

Plate VII., Fig. 1, is a type of a cover trench, it being understood there is no question of firing from it. It gives more cover than a fire trench. Cover trenches with overhead cover are shown on Plate VI., Figs. 3 and 4, and Plate VII., Fig. 2.

Plate VII., Fig. 3, shows a reverse slope, scarped to give cover from indirect fire.

Generally speaking, the only cover there will be time in a hastily fortified position to provide will be *fire trenches* for the *firing line*. Other troops will generally have to trust to natural cover. *Supports* will be better in cover trenches if no such natural cover exists. *Reserves* can usually find cover on the reverse slope of the position.

Communications.—Protected or screened communications from a fire trench to the rear should always be provided if possible.

Plate VII., Fig. 4, shows a type of trench for this purpose, giving cover from both sides, if required. In some cases, as for example the steep chalk slope covered with grass, described on page 27, communication trenches would require an immense amount of labour to conceal. Even if a covered trench of the section shown on Plate VI., Fig. 3, was used, the top would have to be sodded all over in this case. A long length of such trench would hardly be practicable in the field. Open communication trenches will generally have to zig-zag, and need very careful tracing, as otherwise they are liable to be enfiladed.

The positions for fire trenches at the foot of slopes, as has already been pointed out, make communications very difficult. In hastily fortified positions there will be hardly enough men, time or tools to make long lines of communication trench, or, indeed, to do more than use such natural facilities as exist. Much can be done in providing communications screened from view. It is often advisable to rest the flank of a trench on a

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hedgerow running back to the rear, so that the hedge may afford a screened communication.

Even at the foot of slopes it will often be possible to arrange the communications to the rear round the back of spurs, etc.

Where communication trenches have to be made down a hill facing the enemy's positions, it may be often found best and simplest to make a trench straight down the hill along the shortest way; the section to be that in Fig. 4, Plate VII., throwing the earth well back when digging, then roofing the whole trench over with any material available, and throwing back the earth on top, thus providing a covered way. This arrangement is often very useful between supports and firing line, as these distances are usually short.

DRAINAGE OF TRENCHES.

Slope the bottom of the trench away from the foot of the interior slope, and make a gutter at the back. Run the water from this gutter either to soak pits or to some ground lower than the bottom of the trench.

Drainage is very important in all types of trenches, as men cannot maintain a high state of morale if sitting in water-logged trenches.

Even in trenches hastily prepared, it will be well to attend to rough means of drainage from the beginning.

COVER FOR ARTILLERY.

As a general rule the gunners themselves construct cover for their own guns.

When the ground is soft, and no natural cover exists, guns are best covered by being sunk in pits. But when existing banks, with a little modification, afford ready-made cover, or where the ground is hard and favourable for working guns, an épaulment is preferable.

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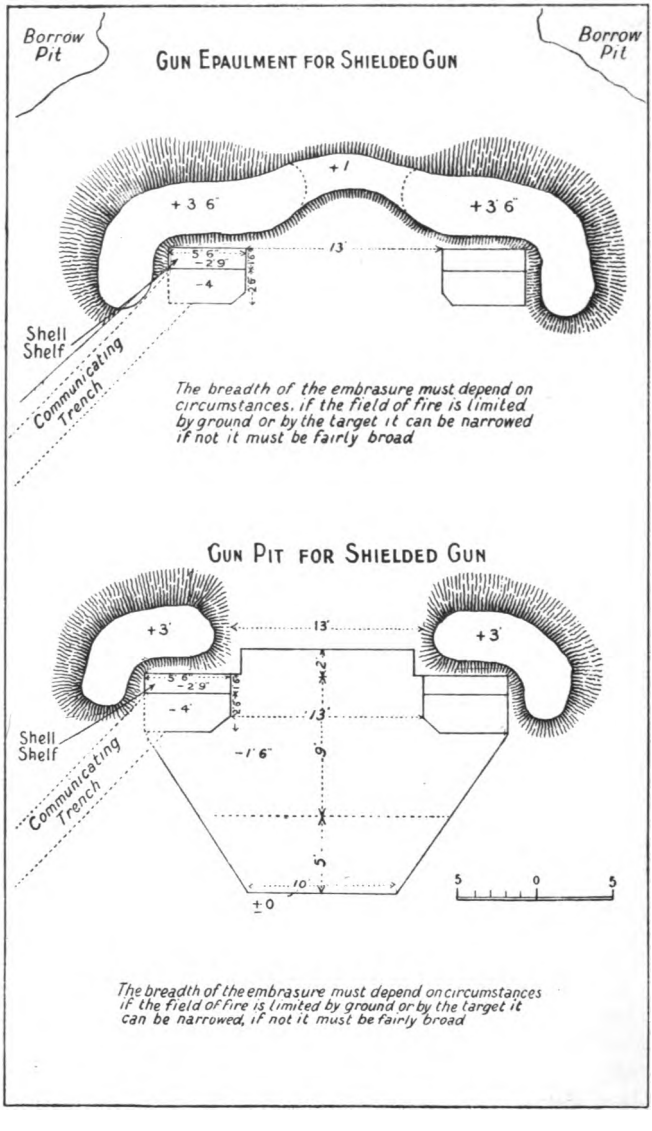

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In a pit, the gunners are better protected than behind an épaulment, but the working and lateral range of guns is more cramped, and they have not such a good view. Again, the guns are under cover quicker in a pit, but on the other hand the gun cannot come into action till the pit is finished, while with an épaulment, fire can be opened at any moment, even while the épaulment is being constructed.

Pits and épaulments may be placed 25 or 30 yards apart. They may be closer than this when space is limited, and sometimes they are connected by trenches, when it is desirable to mass the guns in battery.

An épaulment or a gun-pit of the type shown in Plate VIII. can be constructed by 10 men in 4 hours.

Plate VII., Fig. 5, shows a ridge scarped to give cover for guns.

Plate IV., Fig. 3, shows a section of an entrenchment for a maxim gun.

Field Howitzers, owing to the nature of their fire, can be easily covered by being placed on reverse slopes, behind woods, etc.

If it is considered desirable to make entrenchments for Artillery, two or even more emplacements for each gun may be prepared with communication between them, so that the guns, if driven from one position, may still be employed elsewhere.

Guns of Position may be entrenched on the same lines as above, the height of the parapet being made up to whatever the gun can fire over.

IDEAS BORROWED FROM SIEGE WORKS.

When a carefully prepared position, as for example an interval between two detached forts in a modern fortress, has to be taken, it may be necessary for the attack to approach such a position by occupying successive lines of trenches.

Once some sort of cover has been obtained, it can easily be improved by deepening and widening at night. In

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the attack of a carefully prepared position beginning a new line of trenchwork, even at night, would probably be a most hazardous undertaking, and it is essential for some sort of cover to be got very quickly. This can be done by filling coal sacks, gabions, etc., which soon give bullet-proof protection to the working party, and can finally serve as a revetment to the finished parapet.

It may be impossible to advance over a particularly difficult piece of ground to the position favourable for a new trench by any other means than by extending a narrow deep approach trench in the direction of its length from the old position to the new one. This method would be slow, as only one man could work at a time at the head of this trench, and he would have to keep under cover all the time: this is known as "Sapping."

Howitzers are generally concealed behind natural cover, and require only splinter-proof protection. If a shell fell right into the emplacement it would, of course, wreck it completely, but this would be the case, even if very elaborate measures were taken. The chances of so accurate a shell are remote, and must be accepted. The gunners can get complete protection from shells falling in the vicinity of the howitzers by means of high splinter-proof walls of brushwood and earth constructed round the emplacement. Occasionally this idea might prove useful in a very carefully prepared field position, and might be applied to field howitzers, modifications being made so as not to impair their mobility, *e.g.*, no back wall.

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CHAPTER IV.

REVETMENTS.

A revetment is an artificial means of making earth stand at a steeper slope than it would do if entirely unsupported. The revetments most commonly used in field-works are:—gabions, fascines, hurdles, sand-bags, sods, planks, etc. Most of the regular revetments (except sods) stand at 4 in 1. As has already been pointed out, excavated earth will only stand at 1 in 1, or if trouble is taken to use sods, stones, etc., during construction, about 2 or 3 in 1. Very often the rough revetment will be all that is possible to employ when making the trench, but if the trench is to be occupied for any time this should be replaced by a proper revetment made of the materials available.

Gabions with Fascines are very good for high parapets, being very durable. Moreover they need not be made on the spot, and therefore no special revetting party is required.

Fascines make a poor revetment by themselves. They have some special uses which render them valuable, such as revetting steps, making floorings, roofs, drains, etc. *Sandbags* are so valuable for repairs, that they should be used sparingly for original work. *Sods* take more time and trouble to build than other kinds of revetment, and do not stand at quite such a steep slope, but they are often to be had when nothing else is, and if laid in the spring, the work will be strong and durable. *Canvas* or *continuous hurdle-work* make good revetments, and are easily and quickly made. This is probably the most useful for all-round purposes.

Expanded Metal will in future be much used on Service. It will be carried as an article of store, and be in pieces 6 ft. by 3 ft., so that it can be utilised either as an ordinary bundle or rolled up into the form of a gabion.

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The latter is very light, strong and durable, and can stand vertical in a parapet with moderate command (see Plate XI., Fig. 9).

Gabions in one tier, sandbags and sods will stand without anchoring.

Revetments that are held back by anchoring should be made at a *less slope* than that at which they will be required to stand ultimately, *e.g.*, continuous hurdlework if required to stand at 4 in 1 should be made at 3 in 1, and the slack of the wire will bring it out to 4 in 1.

Gabions are cylinders open at both ends, which, when standing on one end and filled with earth, make a strong revetment. Their usual dimensions are 2 ft. exterior diameter, and 2 ft. 9 in. in length. They may be made of almost any material capable of being bent or woven into a cylindrical form, such as brushwood, Willesden paper, canvas, sheet iron, wire-netting, etc. They are useful for getting cover quickly, but are not a common form of revetment in these days of low parapets.

A *gabion revetment* stands at a slope of 4 in 1. The gabions are given the necessary tilt by resting their inner edge on fascines, sods, stones, etc. They are then filled in with earth which is well rammed into, and all round them. This gives a height of 3 ft. 6 in., which can now be increased in various ways as may be required. (See Figs. 1, 2, Plate XI.). If the revetment should be a high one, its stability is greatly increased by the use of *anchors* made of logs of wood, branches, pieces of fascine, etc., buried about 4 ft. back in the parapet, and connected with the revetment by wire or rope. Brushwood gabions weigh about 50 lbs., and require about 1½ bundles of brushwood. Three men can make such a gabion in two hours. The method of construction is fully explained in the text books.

Various forms of iron gabions have been used. They are easily and quickly made, but should not be employed in future where they are likely to come under common shell fire, as the splinters from them are dangerous.

Jones' steel bands are now replaced as an article of store by bands of Willesden paper. These are

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BRUSHWOOD GABIONS.

Commencement of Waling.

Fig. 1.

Waling.

Fig. 2

Pairing.

Fig. 3.

Fig. 4.

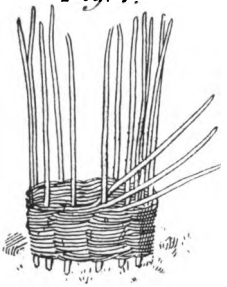

Fig. 5.

Gabion partly of Brushwood rest extemporised.

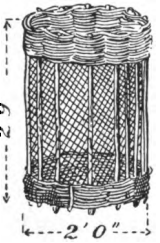

Fig. 6.

BAND GABION.

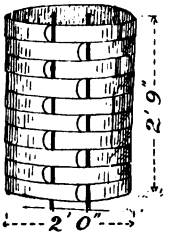

Fig. 7.

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strips of Willesden paper 6 ft. 3 in. long and 3 in. broad. The ends are connected by two copper clips passing through eyelet holes. The weight of a gabion made with these bands is about 13 lbs.

When the gabion is made, the top and bottom bands should be nailed to all the pickets to prevent them dropping out. This is especially necessary if the gabions are to be carried any distance. The joints should be behind two adjacent pickets, and buried in the parapet.

Two men can make this gabion in 10 minutes.

These bands are also useful for continuous hurdle-work.

Wire netting can be used for gabions on an emergency, but not if the soil is dry, friable, or sandy: and improvised gabions can be made with old sandbags, canvas, strips of felt, carpet, etc.

Fascines are bundles of brushwood, 18 ft. long and 9 in. in diameter. For details of construction see text books. Four men can make a fascine in 1 hour. Average weight about 140 lbs. They are particularly useful for revetting steps, making drains, flooring, roads, etc. Four bundles of brushwood are required. (Figs. 1, 2, 3, Plate X.).

Fascines must never be used for *crowning* a revetment, as the effect of a shot striking one would be to carry away a length of 18 ft., and probably a lot of the parapet with it. Crowning should be effected with sandbags, sods, or turf.

Sandbags.—Dimensions, filled with earth and built into a revetment 18 in. long, 9 in. wide, 4½ in. thick. Weight 60 to 70 lbs. Slope 4 in 1. They make a very neat and strong revetment, but they are perishable, and require an extra working party to build them. The ground is first sloped away so that the bottom and succeeding courses of sandbags shall be *perpendicular to the slope of the revetment.* The bags are then laid in alternate rows touching each other; the rows consist of all *headers* and all *stretchers*, care being taken to break joint between the rows until the requisite height is reached. The top row must be a *header* row. As each row is laid, the earth behind it is brought up to the same level, and

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well rammed, before the next row is proceeded with. (Plate XI., Fig. 3.) Two men build and three men fill and tie sandbags. Carriers are required according to distance. Two builders can lay 70 sandbags an hour.

Sods.—Dimensions, when cut, should be 18 in. by 9 in. by 4½in. Slope 3 in 1. They are laid like sandbags in alternate rows of *headers* and *stretchers*, except that there is an equal number of sods used in stretcher and header rows. (Compare Figs. 3 and 4, Plate XI.). Each course is laid at right angles to the intended slope, *turf downwards*, except the top one, which is laid as a header course, *grass uppermost.* The revetment is strengthened very much by pegging each sod to the one below it.

Two builders, if well supplied with sods, should lay 100 in an hour if no pegs are used, but not more than 70 if they have to peg them. Three men can cut 100 sods in one hour.

Hurdles make a good revetment for parapets. They are planted along the line of work, touching each other, and leaning in towards the parapet at a rather gentler slope than that at which they are really required to stand, about 3 in 1, and anchored in the usual way. The settlement of the earth will push them out gradually to the correct slope. Three men will make a hurdle 6 ft. long and 2 ft. 9 in. high in 2½ hours, weight about 56 lbs. For details of construction, see Text-books. (1½ bundles of brushwood are required.)

Continuous hurdle-work is very useful for revetting long lines of parapet. In such cases, it is made on the spot, the pickets being driven in along the line to be occupied at intervals of 12 in. or 18 in. according to their stoutness. The brushwood is better untrimmed, and if two men are told off every 10 ft. or 12 ft. they will finish the revetment to a height of 3½ ft., and anchor it back, in from ½ to ¾ of an hour. It should be crowned with a row or two of sods, as the pickets would not make a comfortable elbow rest. (See Fig. 6, Plate XI.).

Hurdle revetments, etc., depend on the anchoring. If the pickets are weak anchor them at the top and half way up.

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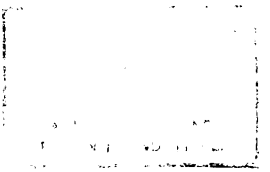

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FASCINES.

FASCINE TRESTLE

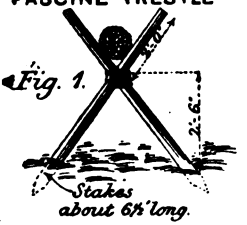


Fig. 1.

FASCINE CHOKER

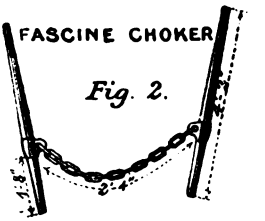


Fig. 2.

Fig. 3.

18 FEET FASCINE, COMPLETED.

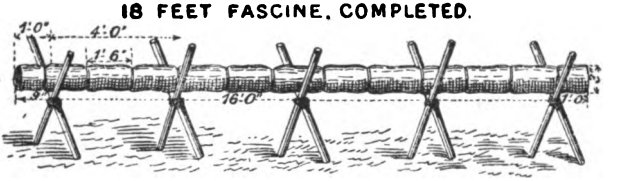
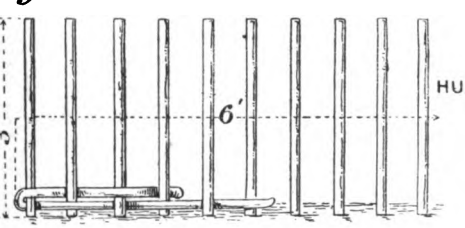
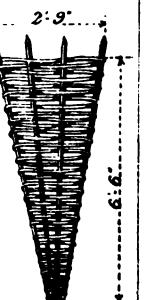


Fig. 4. HURDLES

Commencement of a 6ft Hurdle



HURDLE SECTOR.



Weight 20 lbs.

Fig 6

Fig. 5.

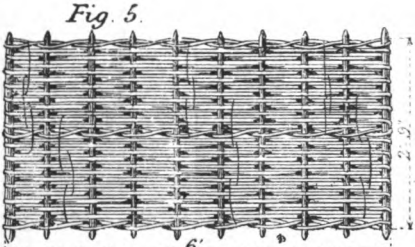


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Fig. 5, Plate XI., shows a revetment where brushwood is simply packed behind the pickets.

Fig. 7, Plate XI., shows how the same idea can be applied to canvas, sheets, blankets, etc. Willesden canvas, the service store, is in long strips 3 feet wide.

Fig. 8 shows a brushwood and earth wall, suitable for splinter-proof partitions, traverses, etc. Canvas, etc., will do equally well in lieu of brushwood.

Hurdle sectors are used for floorings of bell-tents. Sixteen of them will floor a tent 14 ft. in diameter. Two men can make one in 3 or 4 hours. For details, see Text-book.

Other kinds of revetments.—Staves of casks, planks, etc., may be used for revetments in various ways. Planks should never be used in long lengths.

Wire netting, with stakes passed in and out of the meshes, and anchored back to the parapet, forms a good revetment if the soil is not too dry and sandy.

Other expedients will suggest themselves, such as casks, heather, small branches of trees, clods, etc., etc.

The best way of calculating the quantity of materials required to revet any given area is to use the table given in the Manual of Military Engineering for 100 square feet. It need not be remembered.

Gabion revetment—7½ ft. high, 14 gabions, 3 fascines.
Sand-bag ,, —200 bags.
Sod ,, —450 sods (average size of each sod being 18in. × 9in. × 4in).
Sods laid flat for covering slopes—90
Hurdle revetment—9 bundles of brushwood of about 50 lbs. weight each.

In estimating labour, material, etc., a rough calculation has often to be made. There is no need for *minute* accuracy, but make sure that you are on the safe side, and allow enough to get the work done.

In most trench work requiring brushwood, etc., much time and confusion will be saved if brushwood required can be on the spot *before* the work is begun.

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This applies equally well to other materials, which are required during the execution of the work.

For example, in making a parapet 4 ft. 6 in. high, revetted with continuous hurdlework, the revetment will best be made simultaneously with the parapet.

Brushwood is best made up in bundles of about 50 lbs. About 60 bundles form a load for a G.S. wagon (see page 88).

Examples of Calculations for Revetments.

Example 1.—The top and exterior slope of a parapet of a fire trench 1 ft. 6 in. in command and 100 yards long, has to be concealed by carefully sodding.—How many men are required to do this work in 4 hours?

The width of the parapet to be covered with sods may be estimated at about 6 ft., and its length is 300 ft.

$\therefore$ Area to be sodded $= 300 \times 6$ square feet.

$= 1{,}800$ square feet.

But each sod $= 1\frac{1}{2}$ feet $\times \frac{3}{4}$ feet in area.

$= \frac{9}{8}$ths square feet.

$\therefore$ Number of sods $= 1{,}800 \div \frac{9}{8}$

$= 1{,}800 \times \frac{8}{9} = 1{,}600.$

3 men cut 100 sods in 1 hour, say 250 sods in 4 hours.

So we want $\frac{1{,}600}{250} \times 3$, or say 20 men to cut sods.

To settle how many men altogether are wanted for the job is entirely a question of how far the sods are away, and what means are available for carrying them. The carriers in this case could put their sods on to the parapets, as no builders would be required. Probably the sods would not be near the trench—supposing 2 men bring up 8 sods every time and make 20 journeys in the 4 hours.

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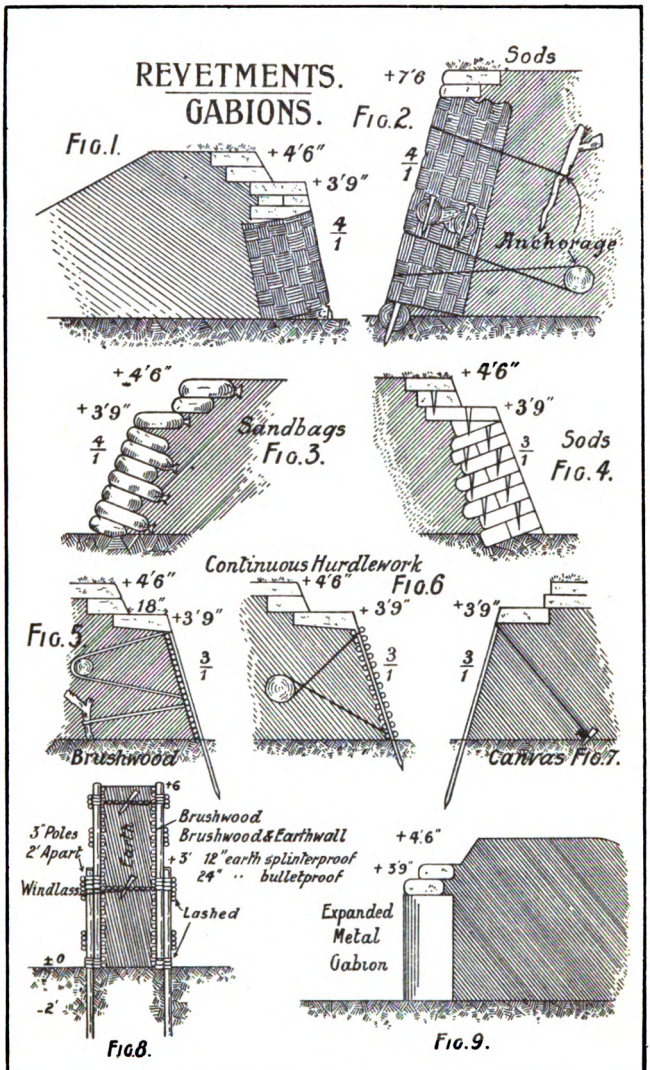

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Two men bring up 160 sods, and about 20 men would be required to carry the sods.

Probably 45 men for the work would not be a bad estimate.

This example is given as a type of what may have to be estimated for in concealing a trench.

Example 2.—What material is wanted to make 50 yards of continuous hurdle revetment, as shown on Fig. 6, Plate XI.?

The height of the Revetment is 3 ft. 6 in., so altogether there are $150 \times 3\frac{1}{2}$ sq. ft. $= 525$ sq. ft.

$$= \frac{525 \times 9}{100} \text{ bundles of brushwood.}$$

$= 47\frac{1}{4}$, or say 50 bundles of brushwood.

If pickets are 1 ft. 6 in. apart, and every other picket is anchored back, we have a binding every 3 ft. or 50 bindings in all. Suppose each binding is 4 yards long, making a liberal allowance for the turn round the fascine, etc., we want $50 \times 4 = 200$ yards of wire. No. 14 S.W.G. would be a suitable size of wire.

To anchor the wire would require 50 strong stakes, which might be picked out from the stouter parts of the brushwood, or 9 fascines. If the fascines were used another 36 bundles of brushwood and 200 yards of wire would be required, and the fascines would be best made beforehand, as they take an hour to make.

To "*crown*" the revetment we have to finish the last foot with sods or sandbags—suppose sandbags are used.

There are 150 sq. ft. of revetment (see page 58).

$$\text{or } \frac{150}{10\emptyset} \times 20\emptyset = 300 \text{ sand-bags.}$$

The total material required would, therefore, be, including the fascines, 86 bundles brushwood (say 2 G.S. wagon loads), 300 sand-bags, 400 yards No. 14 S.W.G. wire.

If work was being done in the 1st relief of the digging (see page 82), 2 men every 10 ft. could do the continuous hurdle work in about half-an-hour, and would then be able to shovel the earth for the diggers. This exemplifies

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the gain of having materials ready on the spot, as during the first ½ hour the shovelling would not be very heavy work.

The "*crowning*" would be done towards the end of the digging when the parapet had some shape—probably next relief.

Two men can build 70 sand-bags in one hour. Three men fill and tie. A sand-bag filled weighs about 50 lbs., so if sand-bags are filled from the trench 3 carriers ought to suffice. A party of 8 detailed as above would do 70 sand-bags in one hour, or say 150 in 3 hours.

Two parties of 8 ought to do the crowning in 3 hours *easily*.

The above examples are only questions of *common sense*, and are not intended in any way to be *conundrums*. It will be noticed that a liberal margin on the safe side is always given.

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CHAPTER V.

EXECUTION OF EARTHWORKS.

Digging Tools and Tasks.

Under the head of intrenching tools are included pick-axes, shovels, spades, crowbars, and the light service intrenching tool about to be issued with the new equipment.

The latter would seldom be used for intrenching work as long as the heavier tools carried in the regimental transport are available.

The G.S. shovel is somewhat lighter than the pattern for R.E., but an untrained man would probably do as much with it as with the R.E. shovel.

With the ordinary intrenching tools *the average untrained* soldier in *easy* soil can excavate 30 cubic feet in 1 hour, or up to 4 hours at the average rate of 20 cubic feet per hour.

In very easy soils or with specially trained men such as sappers, pioneers, etc., increase the rate by 50 per cent.

In very hard soils decrease by 30 per cent.

Length of Reliefs.

A "Relief" is the length of time a man has to work before being relieved.

A man, once he is tired, cannot do much more digging, and therefore, whatever the length of a relief not much more than 80 cubic feet can be expected. If, as is often the case, fighting is expected soon after making cover, a very much lighter task will have to be given. Four-hour reliefs get most work out of the men, but there is no harm, if time is of not much consequence, in arranging for six-hour reliefs and allowing the spare time for concealment, etc., and getting the trench well finished.

The great point to remember in estimating what can be done, is to be well on the *safe* side, *i.e.*, to make sure that what you propose is well within the powers of the men.

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If the soil is not easy about 60 cubic feet is a fair four-hours' task, and in very difficult soil 40 cubic feet would be all that could be done.

Distribution of Tools.

The men digging usually have a pick and shovel each, if the number of tools available will permit of it. How you arrange the distribution of tools is a question that can only be decided by circumstances. As there are usually more shovels than picks, two diggers may share a pick, or one man with a pick may be told off to every pair of diggers. If there are plenty of men and few tools, two men can be told off to each set of tools, and the work can be done in about two-thirds of the ordinary time.

Shovellers.

When the vertical lift exceeds 4 ft. or the horizontal throw exceeds 12 ft., the work of shovelling the excavated earth is naturally harder. If plenty of men are available and you want to keep up the normal rate of work, special men called *Shovellers* must be detailed. The shovellers will vary in number from about 1 shoveller to 3 diggers to 1 shoveller to every digger; and in the latter case can revet the parapet, begin overhead cover, etc., in addition to shovelling the diggers' earth. If shovellers are not employed, the diggers must naturally be given a very much smaller task.

Diggers.

The normal distance apart of diggers is 5 ft.; there is no objection to increasing this to any reasonable distance that will give the men a fair task, but men cannot work closer together than 4 ft.

Although it is laid down the pick must always be used from front to rear, this cannot be done in fire trenches 3 ft. wide. Great care must be exercised when working sideways with the pick.

The number of men and tools wanted for a trench that can be made in one relief can now be easily estimated.

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(i) Settle length of trench to take number of rifles required, and allow extra for traverses.
(ii) Determine what is a fair task per man, both in the trench and passages round the traverses.
(iii) Having thus arrived at the number of men and tools required, allow both in the case of men and tools, *a margin of at least 10 per cent.*

This should be done in all field work, as tools are liable to break, and even if no casualties occur there are bound to be many unforeseen jobs for the reserve men.

The foregoing principles are exemplified practically in the following examples:—

Example 1.—How many men are required to excavate a fire trench 1 ft. 6 ins. command for 50 men, traversed every 30 ft., in 2 hours? The soil is easy, and concealment can be easily obtained, *e.g.*, by placing bracken all over the parapet.

See Fig. 4, Plate III., and Plate V.

The area of the section of the trench is $3 \times 3 = 9$ sq. ft., so if we put men 5 ft. apart the task per man will be 45 cubic feet, which can be completed in 2 hours.

As the time is limited it will be necessary to have a narrower trench round the traverse than that shown on Plate V. Assume it to be 2 ft. wide, 3 ft. deep, and about 12 ft. in length. Excavation round traverse therefore = 2 ft. × 3 ft. × 12 ft. = 72 cubic feet.

Two men to each traverse will, therefore, only have a task of about 36 cubic feet each, and can easily do this in the 2 hours.

Each space between traverses being 30 feet, will accommodate 10 rifles, so that for 50 rifles we require—

50 × 3 ft. = 150 ft. of trench.

With the diggers at 5 ft. apart.

$$\text{No. of tasks} = \frac{150}{5} = 30 \text{ tasks of 45 cub. ft. each.}$$

With say 4 traverses and 2 men per traverse.

No. of tasks = 4 × 2 = 8 tasks.

Total No. of tasks = 38.

Add 10 % = 42.

Tools required.—42 picks, 42 shovels.

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45 cubic feet is a small task for two hours, but concealment and details will take up the rest of the time. The men might, under the conditions, have been given 6 ft. along the line, and task made 54 cubic feet.

With plenty of men available, 84 men could double-man the tools, and get the work done in under $1\frac{1}{2}$ hours.

Generally speaking, units are detailed for work. Thus 42 tasks would represent a suitable job for half a company.

Example 2.—Same conditions as Example 1—Time 4 hours.

Here we can give the men 8 ft. along the line, or a task of 72 cubic feet, and one man can also do the passage round the traverse, task 72 cubic feet.

$$\text{No. of diggers} = \frac{150 \text{ ft.}}{8 \text{ ft.}} = 19 \text{ tasks.}$$

$$\text{Four traverses (each 2 men)} = 4 \times 2 = 8 \text{ tasks.}$$

Total 27 tasks.

10 % 3

Total 30 tasks.

Example 3.—Trench in Examples 1 and 2 has to be recessed. How would you arrange tasks to get this done in a four-hour relief.

See Plate V. The first stage is similar to that in Example 1, and can be completed in 2 hours. The second 2 hours can be devoted to recessing.

There is a recess at every 5 ft.

Excavation for each recess $= 2 \text{ ft.} \times 2\frac{1}{2} \text{ ft.} \times 3 \text{ ft.} = 15$ cubic feet.

This should be completed in half an hour. Therefore 1 man should complete 4 recesses in 2 hours.

$$\text{No. of recesses} = \frac{150 \text{ ft.}}{5 \text{ ft.}} = 30.$$

Therefore $\frac{30}{4} = 8$, or say 10 men (with reserve) would complete 30 recesses in 2 hours.

To accommodate 50 rifles the recessed trench would have to be made 250 ft. long.

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Example 4.—A fire trench for 50 rifles has to be constructed, see Plate V., traversed every 25 ft., recessed and given overhead cover, soil easy and brushwood on the spot.

Detail the working parties, and calculate the tasks, time and tools required.

As each recess occupies 5 ft. of front, 50 rifles will require 250 ft. of trench, and the number of traverses $= \frac{250 \text{ ft.}}{25 \text{ ft.}} = 10.$

Placing the diggers at 5 ft. apart, the task for each digger in the first and second stages (Plate V.) will be 5 ft. × 3 ft. × 3 ft. + 2 ft. × 2½ ft. × 3 ft. = 60 cubic feet.

This should be completed in 3 hours.

The area of the section for excavation in the 3rd Stage (Plate V.) $= \frac{5\text{ft.} + 3\frac{1}{2}\text{ ft.}}{2} \times 4\frac{1}{2}$ feet less 3 ft. × 3 ft.

$= 10$ sq. ft.

∴ Excavation in 3rd stage (diggers at 5 ft. apart)

$= 10$ ft. × 5 ft. $= 50$ cub. ft.

This would take about 2½ hours to complete.

Together with the proper completion of the overhead cover, this would entail working practically for 6 hours.

Traverses.—Excavation 12 ft. long, 3½ ft. wide, 3 ft. deep = 126 cubic feet.

Two men per traverse being detailed, each man's task will be 63 cubic feet, which can be finished easily in 4 hours.

Six hours is too long for one relief in the trench, work being continuous, digging the whole time. It must, therefore, be arranged in two reliefs, the first relief (4 hours) completing the first and second stages (Plate V.) with traverses, and preparing the brushwood, etc., for the overhead cover, and material for concealment. The second relief completes the third stage.

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First Relief.

No. of diggers for trench $= \frac{250 \text{ ft.}}{5 \text{ ft.}} = 50$

No. of diggers for traverse $= 10 \times 2 = 20$

70

Add 10 % 7

Total 77

Tools.—77 picks, 77 shovels, 10 billhooks.

Time.—4 hours.

Second Relief.

No. of diggers (for trench only) $= \frac{250 \text{ ft.}}{5 \text{ ft.}} = 50$

Add 10 % = 5

Total 55

Tools.—55 picks, 55 shovels.

Time.—3 hours.

Example 5.—Trench in Example 2 is to be loopholed. Sand-bags are available in large quantities. How many men are required to do this in 4 hours, loophole 5 ft. apart, centre to centre?

A good sand-bag loophole of the type shown on Plate Va., Figs. 4 and 5, requires 11 sand-bags. In a 30 ft. length of trench we can put 6 loopholes, so altogether 30 loopholes have to be made, requiring 330 sand-bags. Treating the question on the lines of Example 2, Chapter IV., 8 men, organised as 2 builders, 3 fillers, and 3 carriers should make 10 loopholes, requiring 110 sand-bags, in 4 hours. 24 men could do the work.

Reliefs.

The principle in arranging reliefs is to make sure that the work will be finished. Make the first relief the largest task, and the last relief the smallest. Any shortage will then be able to be made up in the last relief.

Reliefs should be divided by vertical lines when this can be arranged, as this leaves a vertical face for the subsequent reliefs to pick down. (See Example 9.)

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Leave the trimming of all slopes to the last relief, as they may stand at a much steeper angle than estimated for. At greater depths than 4 ft. allow slopes of 4 over 1. Rock and chalk will stand vertically.

In addition to above try and equalise the throw of the earth, and arrange for convenience of revetters.

Overhead cover will vary according to the type adopted. Generally it will take a 4-hour relief to make, and require 1 to 2 men for every 5 ft.

Example 6.—A fire trench is to be constructed for 50 rifles on ground sloping to the front, and to be without any command or parapet. See Fig. 1, Plate XII. Soil easy. Time available, 8 hours. How will the work be arranged?

The trench is 5 ft. wide at top, 3 ft. at bottom, and $4\frac{1}{2}$ ft. average depth.

Total length of trench is 50 ft. × 3 ft. = 150 ft.

First Relief.—Place diggers 6 ft. interval to dig a trench 3 ft. wide and 4 ft. deep. See Fig. 1, Plate XII.

$$\text{Task} = 6 \text{ ft.} \times 3 \text{ ft.} \times 4 \text{ ft.}$$
$$= 72 \text{ cub. ft.}$$
$$\text{No. of diggers} = \frac{150 \text{ ft.}}{6 \text{ ft.}} = 25$$
$$\text{Add } 10\ \% = 3$$
$$\text{Total} \quad 28$$

Tools.—28 picks, 28 shovels.

Time.—4 hours.

Second Relief.—The only remaining work will be the slopes of sides, and the bottom 6 in. of trench and elbow rest, or about 7 square feet in section.

Place diggers at 9 ft. interval.

$$\text{Task} = 9 \times 7 \text{ cub. ft.}$$
$$= 63 \text{ cub. ft.}$$
$$\text{No. of diggers} = \frac{150 \text{ ft.}}{9 \text{ ft.}} = 17$$
$$\text{Add } 10\ \% = 2$$
$$\text{Total} \quad 19$$

Tools.—19 picks, 19 shovels.

Time.—4 hours.

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Balancing Parapet and Excavation.

With low parapets under 1 ft. 6 in. command, there is no difficulty in getting earth for the parapet, and there is bound to be a large surplus that has to be spread or piled at the back of the trench.

The simplest form of fire trench is that in which the amount of cover prescribed above is gained by the combination of parapet and excavation, without more than is necessary of either. The 3 ft. by 3 ft. trench with 1 ft. 6 in. command is such a trench. As the command increases, it is necessary to make sure that your excavation will make the parapet.

Generally speaking, in fire trenches a front ditch represents a waste of cover, and makes the trench harder to conceal. On the other hand, if you have plenty of men, by working a party at trench and ditch together, you can get the parapet up in half the time.

Earth, when newly excavated, especially in stiff soils, occupies more space than it did before by about one-seventh to one-tenth of its volume. It is not worth while to allow for this in calculation, as the surplus can always be used in some way, or disposed of. It will be sufficient to take a section at right angles to the line of the parapet, and make the area of the excavation equal to the area of the parapet. This section need only be a dimensioned hand sketch.

On drawings the area in square feet is shown thus $\left|\overline{20}\right|$, the contents in cubic feet thus (80).

All heights above the ground level are marked with a "plus" sign +, those below with a "minus" sign −. The ground itself is ± 0.

Slopes in fortifications are expressed by fractions in which the numerator bears the same proportion to the denominator as the height of the slope does to the base. Thus, if a slope is described as 1 over 1, it means that its height and base are equal; if 1 over 2, that the base is twice whatever the height is; if 3 over 1, that the base is $\frac{1}{3}$ of the height; and so on.

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Parapets of field works being of fixed dimensions, the work of design is simple. The thickness of parapet will be from 2 to 4 ft. The exterior slope will not stand steeper than 1 over 1, and you want it as flat as you can manage to make it. The interior slope can be revetted at 2 over 1 roughly, or 4 over 1 with a good revetment. If time presses the elbow rest might have to be omitted. The following examples will explain the foregoing principles:—

Example 7.—Design a parapet for a fire trench 3 ft. command that can be made in 4 hours in easy soil—revetment to be made roughly of sods. Concealment easily obtained by placing bracken, etc., on the front.

The first thing is to draw a hand sketch of the parapet, see Plate XII., Fig. 2. As time presses we shall have to be satisfied with a 1 over 1 exterior slope and a 2 ft. thick parapet.

Letter the parapet as shown in the figure, and then divide it up into the simplest areas for calculation. Fractions smaller than $\frac{1}{4}$ or even $\frac{1}{2}$ may be neglected.

Area of triangle, D E F $= \frac{1}{2} \times 3 \times 3 =$	$4\frac{1}{2}$ sq. ft.
Area of rectangle, A B E D $= 3 \times 3\frac{1}{2} =$	$10\frac{1}{2}$ sq. ft.
Area of triangle, A B C $= \frac{1}{2} \times 3 \times 1 =$	$1\frac{1}{2}$ sq. ft.
Total ...	$16\frac{1}{2}$ sq. ft.
Deduct the elbow rest, $1\frac{1}{2} \times \frac{3}{4}$ ...	1
Total ...	$15\frac{1}{2}$ sq. ft.

Now to design the trench or ditch the firing step must be 4 ft. 6 in. below A and 1 ft. 6 in. broad if revetted, otherwise 2 ft. 6 in. or 3 ft. Make it 2 ft. 6 in. This gives—

$$\text{C G H K} = 2\tfrac{1}{2} \times 1\tfrac{1}{2} = 3\tfrac{3}{4} \text{ sq. ft.}$$

NOTE.—*The area of a trapezoid* = half the sum of the parallel sides multiplied by the perpendicular distance between them.

The area of a right-angled triangle = half the product of the sides containing the right angle.

The area of any triangle = half the product of any one of its sides, and the perpendicular drawn to it from the opposite angle.

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All that has to be done is to go down another 1 ft. 6 in. and far enough back to make the $11\frac{3}{4}$ sq. ft. required If we go back 4 ft. we get—

$$K\ L\ M\ N = 4 \times 3 = 12 \text{ sq. ft.}$$

or a trench giving $15\frac{3}{4}$ sq. ft., which will make the parapet. Giving men 5 ft. along the line the task for 4 hours would be $77\frac{1}{4}$ cubic feet, but 4 ft. tasks would only give 63 cubic feet. As the lift is over 4 ft., if spare men are not available 4 ft. tasks would be best. Having found the area of a parapet, it is simple to see if a ditch is wanted, or more than one relief is necessary, by multiplying this area by 5 or 4 as a minimum. If the result is more than 80, obviously one of these courses must be taken. Trenches cannot be made for fire kneeling, as in the case of low commands.

Example 8.—Soil in Example 7 is difficult, and 50 cubic feet is a fair 4 hours' task.

The parapet is unchanged. Men can be put at 4 ft. intervals in the rear trench, as we want to get as much cover as possible out of the digging. See Fig. 3, Plate XII.

With firing step as before, as area of the trench cannot exceed $\frac{50}{4} = 12\frac{1}{2}$ sq. ft. K L M N can only be $12\frac{1}{2} - 3\frac{3}{4} = 8\frac{3}{4}$ sq. ft., say 2 ft. 6 in. wide, which allows a small margin, and $K\ L\ M\ N = 3 \times 2\frac{1}{2} = 7\frac{1}{2}$ sq. ft.

Our trench therefore gives only $7\frac{1}{2} + 3\frac{3}{4} = 11\frac{1}{4}$ sq. ft., and the remaining $4\frac{1}{4}$ sq. ft. must be got from a ditch which may be any convenient shape, as it is only wanted for getting earth.

The rear trench party would have a task of $4 \times 11\frac{1}{4} = 45$ cubic feet, with 4 ft. tasks, and the front ditch party might have 10 ft. tasks along the line of $42\frac{1}{2}$ cubic feet.

Traversing would best be done by making a wall of earth held up by brushwood, canvas, etc., between posts (see page 37). It would be difficult in a short time to do much more than traverse the firing step.

Example 9.—Design a redoubt parapet 4 ft. 6 in command, with overhead cover in rear trench, as Fig. 1, Plate XIII. Good sand-bag loopholes at 5 ft. intervals centre to centre to be provided. Make an estimate of

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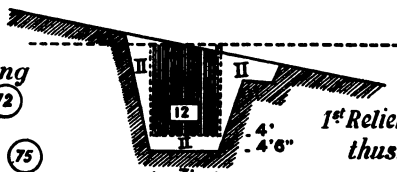
RELIEFS.

FIG. 1



1st Relief Tasks 6' along the line (72)

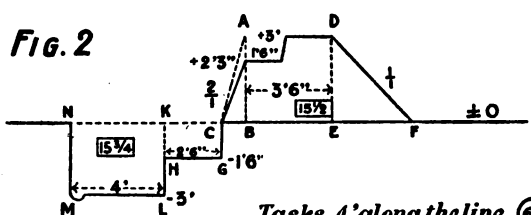
Traverses (75)

1st Relief shown thus. ■

2nd Relief Tasks 8' along the line. (56)

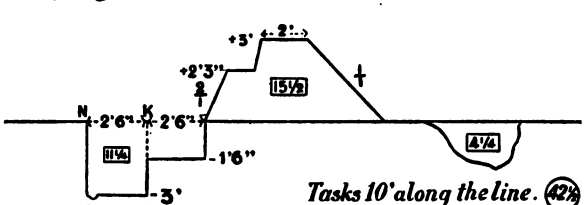
BALANCING PARAPET AND EXCAVATION.

FIG. 2



Tasks 4' along the line (63)

FIG. 3



Tasks 10' along the line. (42½)

Tasks 4' along the line. (45)

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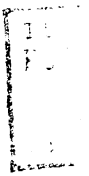

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BALANCING PARAPET AND EXCAVATION.

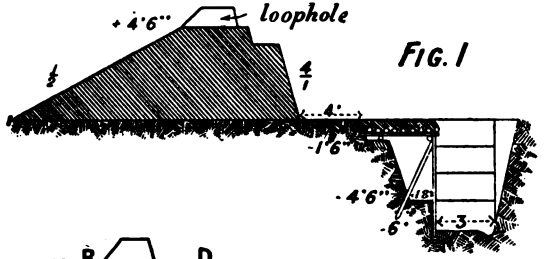


FIG. 2 Handsketch

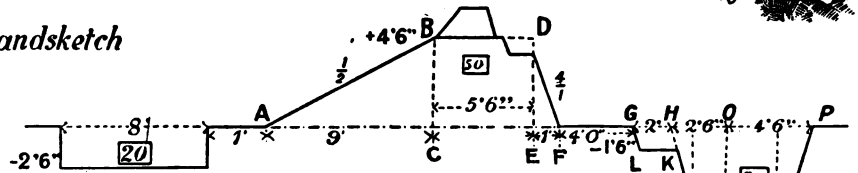
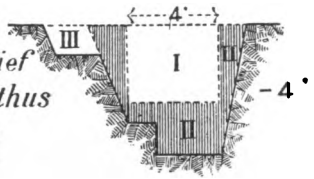


FIG. 3



2nd Relief shown thus

FIG. 4

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men, time, and materials required to complete 50 yds. of this parapet in easy soil. Brushwood is available for revetting and for overhead cover.

This example, which may appear somewhat complicated, is really only an application of common sense to details. The first thing to be done is to draw the section of the parapet, Fig. 2, Plate XIII., and letter it as in the figure.

Next to obtain the sectional area of the parapet in square feet:—

Area of triangle, A B C	$= \frac{1}{2} \times 9 \times 4\frac{1}{2}$	$= 20\frac{1}{4}$ sq. ft.
„ rectangle B C E D	$= 5\frac{1}{2} \times 4\frac{1}{2}$	$= 24\frac{3}{4}$ „
„ triangle D E F	$= \frac{1}{2} \times 4\frac{1}{2} \times 1\frac{1}{8}$	$= 2\frac{1}{2}$ „
Add for loopholes, say	$2\frac{1}{2} \times 1\frac{1}{2}$	$= 3\frac{3}{4}$ „
		$51\frac{1}{4}$ „
Subtract area of elbow-rest	$1\frac{1}{2} \times \frac{3}{4}$	$= 1\frac{1}{8}$ „
Area of parapet.....		$= 50\frac{1}{8}$, say 50 sq. ft.

If the trench is made convenient for the overhead cover, the remainder of the earth necessary can be got from a ditch in front.

The area of the rear trench is obtained in the same manner:—

Area of figure O P Q R	$= 6 \times \frac{1}{2}(4\frac{1}{2}+3)$	$= 22\frac{1}{2}$ sq. ft.
„ „ O N M H	$= 4\frac{1}{2} \times \frac{1}{2}(2\frac{1}{2}+1\frac{1}{2})$	$= 9$ „
„ „ G H K L	$= 2 \times 1\frac{1}{2}$	$= 3$ „
Area of trench		$= 34\frac{1}{2}$ „

Of this, about $4\frac{1}{2}$ sq. ft. is required for the overhead cover, which leaves 30 sq. ft. for the parapet.

Therefore the sectional area of the ditch will be $50-30=20$ sq. ft.

The ditch as a rule may be taken to be a shallow one, so that 8 ft. broad and $2\frac{1}{2}$ ft. deep will give the required amount of earth.

Next to arrange the reliefs necessary for the digging. See Fig. 3, Plate XIII.

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The 1st relief of the trench may be got by digging a hole 4 ft. wide and 4 ft. deep, as shown in Fig. 3, Plate XIII. This gives a task of 80 cubic ft., with men at 5 ft. interval, and leaves a good platform for the shovellers to begin the revetment. Shovellers equal in strength to the diggers would soon get the revetment done. See Example 2, Chapter IV.

The 2nd relief of the trench could complete all but the shelf for the overhead cover. Task at 5 ft. intervals 77½ cubic feet. An equal number of shovellers to the diggers who would crown the revetment in addition to shovelling would be necessary. See Example 2, Chapter IV.

The 3rd relief of the trench would only have 15 cubic feet to do, but there is the overhead cover to put up, and each digger might well have a shoveller to assist him.

In the ditch the 1st relief might be as shown on Fig. 4, Plate XIII. The tasks for diggers at 5 ft. interval would be 75 cubic feet, and a shoveller to every two diggers should suffice.

The second relief would only be 25 cubic feet at 5 ft. intervals, but a shoveller should be allowed to every digger as the loopholes have to be made this relief. See Example 5. At the corners of a redoubt there is bound to be a shortage of earth. This could be made up from the front ditch by detailing a special party, 2nd, and perhaps 3rd relief, who could deepen or widen the ditch opposite the corners.

The work could be done in 3 reliefs of four hours, and the men, time and materials required for 50 yards of this section is shown in the following table:—

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Where at Work.	Nature of Work.	No. of Men.	Task.	Picks.	Shovels.	Remarks.
Trench	Digging	30	5 ft. (80)	30	30	100 ft. tape and 2 6 ft. rods.
Trench	Shovelling and Revetting	30	—	—	30	1 G.S. wagon loads brushwood, ¼ mile 14 S.W.G. wire, 10 pliers, 15 billhooks, 5 mauls, 15 handsaws.
Ditch	Digging	30	5 ft. (75)	30	30	
Ditch	Shovelling	15	—	—	15	
	TOTAL 1ST RELIEF	105	—	60	105	
Trench	Digging	30	5 ft. (77½)	30	30	
Trench	Shovelling and Revetting	30	—	—	30	300 sand-bags.
Ditch	Digging and loopholing	30	5 ft. (25)	30	30	
Ditch	Shovelling and loopholing	30	—	—	30	600 sand-bags.
	TOTAL 2ND RELIEF.....	120	—	60	120	
Trench	Digging and putting up overhead cover	30	5 ft. (15)	30	30	
Trench	Putting up overhead cover	30	—	—	—	3 G.S. wagon loads brushwood, ¼ mile 14 S.W.G. wire, 5 mauls, 10 pliers, 15 handsaws, 15 billhooks.
	TOTAL 3RD RELIEF	60	—	30	30	

The number of tools required is greatest number of each sort used in any one relief. Allowing a margin in the case of men and digging tools we have.

Men required { 1st relief, 120. 2nd relief, 135. 3rd relief, 70.

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Tools required.—70 picks, 135 shovels, 5 mauls, 10 pliers, 15 billhooks, 15 handsaws, 100 ft. tape, 2 6ft. rods.

Material required.—4 G.S. wagon loads brushwood, ½ mile No. 14 S.W.G. wire, 900 sand-bags.

The above example shows how necessary it is to think out beforehand the arrangement of work, especially when tools and material have to be requisitioned for. Approximate accuracy only is required, provided it is on the safe side.

In practical fortification it is essential to have a knowledge of what can be done in a given time. It is hoped a careful study of the preceding examples will enable the student to adapt himself to any given conditions. Several examples are added for practice at the end of the book.

Tracing and Profiling.

It is not necessary to trace fire trenches by day. At night tracing tapes would be useful to mark where the trenches should be. Tracing tapes are useful for complicated works like redoubts.

Profiling is unnecessary for works of low command. (For Description see Text Books.)

The method of extending men for work is laid down in Infantry Training.

Generally speaking, the rough measurements necessary for fire trenches can be done with the tools themselves. The helve of the new pattern pick, *e.g.*, is 3 ft. long. A 6 ft. rod, if obtainable, will be useful, but is not an essential.

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CHAPTER VI.

FIELD OF FIRE.

In most positions a certain amount of preparation of the foreground will be necessary to give a good field of fire to the defenders. As pointed out in Chapter II., a field of fire is the most important essential of the defence. Cover has been treated of in the preceding chapters solely for the sake of convenience. The amount of clearing necessary to obtain a good field of fire is a most important point to consider when selecting a position. A natural field of fire is always to be preferred to an artificial one.

In countries such as England the field of fire is often very limited, and in many cases it is hard enough to procure a field of fire for even *close* ranges.

In arranging for a field of fire it is not necessary to make a desert of the foreground. It is surprising, even in very close countries, how little *judicious* clearing will provide a fair field of fire.

Generally speaking it is entirely a question of time and tools how much can be done. The great point to remember is to begin by clearing your *immediate front* and work outwards. Every natural feature that is interfered with helps to give away the measures of defence, and makes concealment and surprise more difficult.

Great advantage can be gained by leaving a natural screen in front of the position.

Natural objects, in accordance with the principles for obstacles laid down in Chapter IX., should also be left.

By *judicious* clearing of the foreground is meant—

(i) To get as much field of fire as the time and tools at disposal will allow.

(ii) To only execute *essential* clearings, and in no case to remove natural screens or obstacles unless absolutely necessary.

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When clearing the field of fire *range-marks* should be provided at known ranges from the trenches for distances beyond 500 yards.

WOODS, ORCHARDS, BRUSHWOOD, ETC.

Large scattered trees give less cover when standing than if cut down, and may sometimes be useful as range-marks. Unless they are required for other purposes and can be removed, it will generally be useless to cut them down.

Sometimes large trees may form a useful range-mark to the enemy, in which case they can be cut down and left lying.

In clearing woods, when there is not time to clear all you think necessary, the difficulty can often be met by making avenues down which you fire, and entangling the part that is not cut down, by forming an obstacle along the edges of the cleared stuff. The enemy is then confined to particular lines of advance, and his line of attack broken up. This is particularly applicable to thick brushwood, tropical growths, etc., which already form a very effective obstacle.

In orchards and many woods, it is important when deciding on the field of fire to put your eye down to the level of the man in the trench. Very often an excellent view is obtainable through the tree trunks, and no clearing at all is needed. This applies particularly to fire on level ground or glacis slopes.

When the trench is well above an orchard, or wood, however, you look down on the tree tops and clearing is necessary. Even in this case, it is not necessary to clear every tree, probably clearing every third or fourth tree will suffice. When clearing a field of fire the work should be viewed from the trenches as it progresses.

No better screen could be well imagined than a large untouched orchard, but this must not of course interfere with the field of fire.

Another point to be remembered in clearing woods, etc., is that very often trees cut down will give much more cover to the enemy than if they had been left alone.

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For this purpose it must be decided what is going to be done with the cleared stuff. It may be dragged to form abatis, or to fill up hollows or unseen ground, or simply dragged to the edge of the clearing farthest from the trenches. Brushwood will often be wanted for revetments, etc., in other parts of the position. Small brushwood that is not wanted for this purpose can be left lying if it does not give cover.

It takes about two men to drag away, or cut up into smaller stuff, what one man cuts down; but of course everything depends on how far the stuff has to be dragged. The point to remember is not to give the whole of the party cutting tools, especially if (as is usually the case) tools are scarce. Generally cutting tools for about half of the party will meet the case, the men without tools dragging the cut stuff away. Some rope will come in useful. If carts and horses can be got, they will be very useful for this purpose, and will mean a great saving of men. It is of course very difficult to make an exact estimate of the amount of work required to clear a field of fire; but if used in accordance with the principles of the preceding chapter, the rules given in the Text Books will give a very fair estimate of what can be done.

With all cutting tools it is important to keep them sharp. Everyone who has tried to cut down brushwood with a blunt bill-hook will appreciate this. The point to remember is to have men detailed at the grindstones, etc., to sharpen tools as they require it.

A man can cut 100 square yards of *brushwood* in 4 hours. With men spaced 4 yards apart, each man should cut 25 yards to his front.

It takes a party of equal strength to collect, sort, and bind. If the brushwood is wanted elsewhere it should be made up into bundles of about 50 lbs. each. (See page 61).

A party nearly equal to the strength of the parties for cutting and binding will be required to load these bundles into carts. If the party have to drag it, the number will depend on the distance. Thus, for cutting 2,500 square yards of brushwood, or about half an acre in 4 hours, a

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party of 25 men would be required for cutting, 25 men for binding, and 15 men for loading up. The men cutting should all have cutting tools, and the binding men may well have them too. In addition there will be required grindstones or whetstones, hedger's gloves, and some rope about 1½ inch size for wagon lashings. An average acre in Kent produces about 30 bundles.

Example 1.—How many men will be required to cut and load up into carts the brushwood required in Example 9, Chapter V., in 8 hours?

Four G.S. wagon loads or 240 bundles are required. Take the table for an acre which produces 14 wagon loads, given in the "Field Service Pocket Book," this will give the following:—

40 men cutting 40 men binding 20 men carrying	300 bundles.
Total 100 men.	

This will give a fairly correct result.

Example 2.—How long will it take 10 men with cutting tools to clear a path 100 yards long and 6 feet wide inside the front edge of a wood of brushwood?

The task per man is about 20 square yards, and work should be done in an hour. In this case only a cutting party is wanted.

A good rough rule for felling trees up to 1 foot in diameter is that one man with a felling-axe will take a minute for every inch in diameter.

A hand-axe is only half as efficient as a felling-axe, but with an inexperienced man the difference would not be very apparent. The hand-axe and hand-saw are only suitable for felling small trees. The saw is the best tool of all provided measures are taken to keep the weight of the tree from jamming the saw. This can be prevented by wedging, or pulling the tree over with a rope so as to keep the cut open.

With untrained men you will be on the safe side in using the hand-axe as a guide and allowing 2 minutes for

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every inch in diameter, except in very soft wood such as fir, larch or poplar, when half this can be allowed.

The time to cut down trees larger than 1 foot in diameter varies as the cube of the diameter.

Example 3.—A cherry orchard measuring 300 yds. × 200 yds. has trees 5 yds. apart, average diameter 7 inches. It is estimated to clear about every third tree. How many men will be required to do this in four hours? Plenty of men are available.

Each tree occupies 5 yds. × 5 yds. = 25 square yds.

There are about $\frac{300 \times 200}{25}$ = 2,400 trees.

One-third of these, viz., 800, have to be cut down. A 7 in. tree will take a man 14 minutes. In 4 hours a man could do $\frac{240}{14}$ = 17 trees; but say 14 trees to make sure. We shall therefore require $\frac{800}{14}$ = 57 men. Adding 10%, 63 men with cutting tools will be required to actually cut the trees down.

To drag them away will probably require twice as many, but this entirely depends on the distance the trees have to be dragged. Total number is 126 + 63 = 189 men, or say 200 men and 100 cutting tools.

The men cutting down the trees may have hand-axes, hand-saws, felling-axes, etc.; the remainder bill-hooks. One or two grindstones would be wanted and all the rope obtainable.

This example is perhaps worked out on too generous lines for work in the usual run of hastily-fortified positions, but it is introduced to impress the need of calculating on the *safe* side, and the student will have no difficulty in forming his own conclusions. In a hastily-fortified position a very fair show would be made with 100 men and 50 cutting tools, but you would not complete the work.

Clearances necessary in orchards can generally be estimated for from the map, if amount necessary, average size and distance apart, and nature of the trees is noted on the ground. The above example is intended to convey this idea.

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Example 4.—A large softwood tree 2 ft. in diameter is on the flank of a fire trench, and it is considered necessary to remove it. How long will this take 4 unpractised men with felling-axes?

Twelve inches softwood takes one man 12 minutes. As trees vary according to the cube of the diameter, a 2 ft. tree will take one man 8×12 minutes $= 96$ minutes. Four men ought to do this in 24 minutes, say half an hour.

HEDGES.

Thick hedges *parallel* to the front, that interfere with the defenders' fire, must be cut down. Thin hedges may form a good screen and can be left alone if they do not interfere with the defenders' fire. Hedges *perpendicular* to the front can usually be left alone, and so may hedges running *obliquely* to the front, provided that both sides of them can be swept by the defenders' fire.

If any cross fire is spoilt by leaving such hedges standing they must be cut down.

Chapter VII. deals with utilising hedges for cover and as obstacles.

Every man cutting down hedges should have a hand-saw and a hand-axe, or bill-hook, if tools are available. If hedges are very thick and have to be cleared away, allow a party equal to the party cutting down. The time taken to cut down hedges will of course vary considerably according to the nature of hedges. On an average for thin hedges with very thin stems (say about $\frac{1}{2}$ in.) a man ought to do 40 yards in 4 hours, and about 15 yards in 1 hour.

With very thick hedges (stems about $2\frac{1}{2}$ in.) 15 yards would be a fair 4 hours' task.

About 25 yards as a 4 hours' task per man, will form a fairly safe guide for most hedges.

Example 5.—You have 50 men with 50 cutting tools, available for cutting down hedges. How much can be done in 4 hours?

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$50 \times 25 = 1{,}250$ yds.—If hedges were thick and many of them had to be dragged away, you could only do about half this. This example is intended to illustrate how to treat hedges when working out a scheme of defence on a map.

WALLS, BUILDINGS, ETC.

Weak walls can usually be battered down by using a rail or tree trunk.

To demolish strong walls and buildings will usually entail the use of explosive. Not only is the supply of explosive generally very limited, but after the demolition has been effected, the ruins must be spread and levelled so as not to give any cover.

A house that has been blown up will often give more useful cover in its ruined state than before.

The point to remember is that it takes *a very large party to level the ruins of a moderate sized house.* At least 100 men for 4 hours, would be required for quite a small farmhouse, for example. Crowbars and picks would be the most useful tools. In preparing for defence a hastily-fortified position, it is no good sending a few men with gun-cotton to blow down a house. As probably you will not have enough men to complete the spreading and levelling of the ruins, most houses will have to be left alone, unless it is absolutely essential to demolish them.

In positions, prepared more deliberately, of course much more can be done, and large parties can be detailed for this work.

A house commanded by the guns of the defence, would not be a very comfortable position for the enemy to occupy. Wooden sheds, etc., can of course be easily burnt.

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HOLLOWS, UNSEEN GROUND, ETC.

Hollows, etc., in your immediate front can be filled up with the debris from clearings. There is little use in filling up a hollow with obstacles, if the enemy can get into it without exposing himself to fire.

CROPS, ETC.

Standing Crops may often screen a fighting line. The narrow belt that affords them cover may be left standing, and the rest trodden down.

A *hop field* often makes an excellent screen, and a very good field of fire can often be obtained through the poles, just as in the case of orchards. It furnishes, if cleared, excellent material for improvised obstacles.

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CHAPTER VII.

IMPROVISED FIELD DEFENCES.

It will often happen that the best defences, or (with reference to the time and means available for preparation) the only possible ones, are those that can be improvised on the spot out of existing features, natural or artificial, such as hedges, banks, walls, and so forth. No precise rules for the best way of turning these to account can be laid down. It will generally be a matter of common sense, but the various devices most commonly resorted to should be read, and an attentive study of Plates XIV., XV., and XVI., in conjunction with the examples and hints herein given, will well repay the trouble expended on them.

Hedges.—Hedges may be useful in any one, or more, of the following ways:—

1.—As obstacles.

2.—As screens, giving cover from view, but not from fire, unless banked up with earth, to which they may then form a revetment.

When utilised as obstacles, they should run parallel to the defenders' front, and be within 300 yards of it. The main branches must be half cut through at the ground level, and then pulled over towards the enemy, and the tops interlaced and picketed to the ground, forming in fact a regular entanglement.

In preparing a hedge for defence, you have only to follow the same general principles that govern the design of trenches. The special points to remember are:—

(i) No excavated earth should show *in front* of the hedge. The hedge will be used as a revetment to the exterior slopes of the parapet and spare men will be required to make up weak places with boughs, wire, etc., and, in case of thick

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hedges, to cut holes for the rifles to fire through. A small proportion of cutting tools will, therefore, be generally useful in the preparation of hedges for defence.

(ii) The roots will make digging harder. A smaller task must, therefore, be reckoned on than for a trench.

The parapet must, of course, be *bullet-proof* at the top. Owing to the exterior slope being revetted by the hedge the area of the section of the parapet is smaller than for a trench of similar command.

The *command* will, as in trenches, be kept as low as possible and only made sufficient to give a good field of fire.

Hedges are of many kinds. There is:—

(*a*) The simple hedge by itself.

(*b*) The hedge with a ditch on the inside.

(*c*) The hedge with a ditch on the outside.

(*d*) The hedge with a ditch on both sides.

(*e*) The hedge on the top of a bank, with a ditch on one side of it, or on both, etc., etc., etc.

(*a*) Taking first the case of a hedge by itself, earth will be got from a trench in rear and piled up against the hedge to height required. The size of this trench will depend upon the time available. Spare earth can be deposited in rear of trench.

(*b*) With a ditch already existing on your own side of the hedge, if time presses, it must be used as it stands. The men must line the ditch, and using the hedge as a screen, fire through it. The ditch can be improved, as time permits, as in (*a*).

(*c*) A hedge with a ditch on the outside. Unless you can fire from the outside ditch as it exists and use the hedge as a background, act as in (*a*).

(*d*) A hedge with a ditch on both sides may possibly be used as it stands, otherwise proceed as in (*a*) and (*b*).

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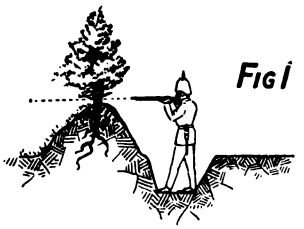


Fig 1

Fig.2.

Simple hedge
Limited Time
Fire Kneeling.

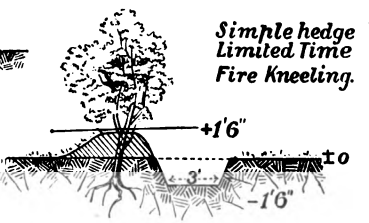


Fig.3.

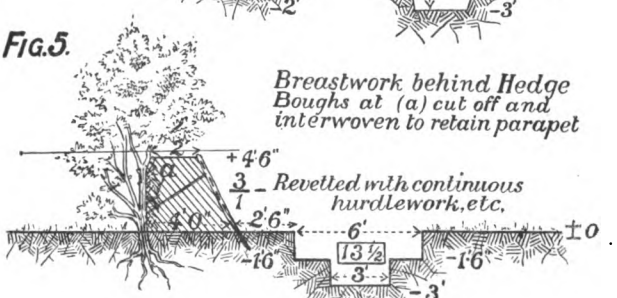
Natural Ditch
in rear

Fig.4.

Natural Ditch
in front

Fig.5.

Breastwork behind Hedge
Boughs at (a) cut off and
interwoven to retain parapet



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(*e*) A hedge on a bank, with or without a ditch, can often be used as it stands (Fig. 1, Plate XIV.), or a very little labour expended on it in one of the methods indicated above, will turn it into a good cover.

Hedges sometimes form very good screens for field guns. It would generally be advisable for the guns to be in action some distance, say, 150 to 300 yards, behind the hedge, as it will be more difficult then for the enemy to obtain the range.

The following examples will bring out most of the points to be considered in preparing hedges for defence, and are worth careful study.

Example 1.—One hour is available to prepare the hedge shown in Fig. 2, Plate XIV., for defence. How much can 50 men do in the time? 1 ft. 6 in. command gives a good field of fire. Soil is easy.

The time being so limited, there is no time to make a trench for fire standing. A trench for fire kneeling and a parapet 2 ft. thick at the top, without an elbow rest, is all that can be attempted.

The task, with men at 5 ft. interval, will be $5 \times 4\frac{1}{2} = 22\frac{1}{2}$ cubic feet, which makes allowance for the roots, etc.

Fifty men could make about 80 yards of this section.

Example 2.—The hedge shown in Fig. 3, Plate XIV., has to be prepared for defence. The bank it stands on is 2 ft. 6 in. high and 5 ft. wide at the bottom, and there is a ditch behind the hedge about 4 ft. wide at the top and 2 ft. deep. 1 ft. 6 in. command will give a field of fire. $1\frac{1}{2}$ hours is time available. How should it be prepared for defence? Soil is easy.

By cutting down the bank to + 1 ft. 6 in. we get a bullet-proof parapet, 2 ft. thick at the top and an elbow rest. Call this 3 sq. ft. for calculation. Most of the trench is ready made, say 5 sq. ft., and only $4\frac{1}{2}$ sq. ft. has to be excavated to give cover for fire standing and provide a steep interior slope. With men at 5 ft. interval the task would be $5 \times (4\frac{1}{2} + 3)$ cubic feet $= 5 \times 7\frac{1}{2} = 37\frac{1}{2}$ cubic feet, which can be done in $1\frac{1}{2}$ hours.

All the earth is put at the *back* of the trench.

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Example 3.—The hedge in Fig. 4, Plate XIV., has to be prepared for defence. In front is a natural ditch about 3 ft. wide and 2 ft. deep. The hedge is on a bank 1 ft. 6 in. high, and 5 ft. broad at the bottom. Two hours is time available, 1 ft. 6 in. command gives a field of fire. How should it be prepared for defence? Soil is easy.

The natural ditch is no use, as there is time to make a 3 ft. × 3ft. trench behind the hedge. This, with the fairly bullet-proof bank already existing, gives cover for fire standing. Task at 5 ft. intervals $5 \times 9 = 45$ cubic feet, which can be done in two hours. The earth is put at the *back* of the trench.

Example 4.—The strong high hedge in Fig. 5, Plate XIV., has to be prepared for defence. 4 ft. 6 in. command is necessary to see the ground in front. Plenty of brushwood is available close at hand. How many men and tools will be required to prepare 50 yards of the hedge for defence in four hours? The soil is very easy.

Little time is available for preparation considering the command of the work, and the parapet will have to be kept to its minimum dimensions. Using the strong hedge as a revetment and revetting the interior slope with continuous hurdlework, say 2 ft. at the top, 4 ft. 6 in. high, and 4 ft. at the bottom = $13\frac{1}{2}$ sq. ft. in area. Obviously the elbow rest cannot be provided as its provision would mean 4 sq. ft. extra.

The trench is mainly to give earth for the parapet, cover being also considered. The trench in Fig. 5 gives $13\frac{1}{2}$ sq. ft. and will make the parapet.

At 5 ft. interval the tasks for diggers would therefore be $5 \times 13\frac{1}{2} = 67\frac{1}{2}$ cubic feet, and as the roots are some distance away, this should be done in four hours.

The revetment of interior slope can be thought out as in Example 2, Chapter IV. It will require $\frac{9 \times 150 \times 9}{2 \times 100} =$ 60 bundles of brushwood, or 1 G.S. wagon load, and 200 yards of No. 14 S.W.G. wire, and will take men at 5 ft. intervals about half hour to put up. The hedge will make an excellent anchor.

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The men who make this revetment will also have to strengthen the hedge in front (for which allow another 200 yards of wire) and can act as shovellers. Rough loopholes will also have to be cut in the hedge.

The work can therefore be arranged thus:—

30 *diggers* at 5 ft. interval. Task 67½ cubic feet. 30 picks and 30 shovels.

30 *shovellers* strengthening hedge, revetting interior slope and cutting rough loopholes. 30 shovels, 10 pliers, 15 bill-hooks, 5 mauls, 15 hand-saws (as in Example 9, Chapter V.). Quarter mile No. 14 S.W.G. wire, and 1 G.S. wagon load brushwood.

Add 10% to men and entrenching tools.

Say 70 men, 35 picks, 70 shovels, etc.

If brushwood has to be cut while work is going on, detail a separate party to do this on the lines of Example 1, Chapter VI.

WALLS.

A 9-inch brick wall will be bullet-proof, but is liable to be penetrated at the joints by volleys, machine guns, etc. Walls 1 ft. 2 in. thick and over have no through joints.

Walls are useless for cover against artillery fire. Shrapnel shell, with percussion fuze, can penetrate most walls, and the common shell would have its maximum effect on a vertical face, and would be helped in its effect by the splinters of the wall. Cover might be obtained from artillery fire by putting men behind 2 walls, one wall about 10 ft. in front of the other. The front wall would have to be at least 2 ft. thick to burst any shell hitting it.

For defence at night time walls and buildings may be invaluable.

The point to remember is that during an artillery bombardment men will find better cover in a trench, and it is therefore not much good trying to make the wall able to resist artillery. When the artillery duel ceases and the attacking infantry advance, a defended wall would be of

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the greatest value, provided the defenders are near enough to man it in time. This can often be arranged by making a *cover* trench a little way behind the wall. Sometimes it will be better to knock down the wall and make a *fire* trench. Defended walls will be wanted most when the foe is at close quarters, and therefore the principal points to attend to are:—

(*a*) To loophole, or notch them in such a way, that they shall be useless to the enemy.

(*b*) To take care that your own men are adequately covered.

(*c*) To provide flank defence if possible.

(*a*) This can be done by making loopholes about 6 ft. above the ground on the enemy's side.

(*b*) By providing head cover, unless wall is very low and time is limited.

(*c*) As the result of (*a*) there will be dead ground right under the wall. To cover this flank defence is required.

If time permits, tambours or small projecting stockades (see Chapter VIII.) may be built out from the wall.

Very often the wall itself, if not in one straight line, will allow of flank defence.

A "machicoulis" gallery, by which fire is delivered vertically downwards, is another way of covering the dead ground at the foot of a wall in a house (see Chapter X.).

Two tiers of fire will be especially useful in portions of wall intended for flanking fire over the remainder.

Walls between 4 *ft. and* 4½ *ft. high* can be used as they stand. If time permits give head cover, either by making it on top of the wall or sinking a trench behind the wall, or by firing kneeling. In the two latter cases wall may be notched or loopholed. Also, if time permits, sink a small trench in front of the wall to prevent it being used by the enemy.

Walls of less height than 4 ft. may be treated in similar fashion. The excavations will have to be deeper if the same measures are taken to provide head cover and a

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DEFENCE OF WALLS.

FIG.1.

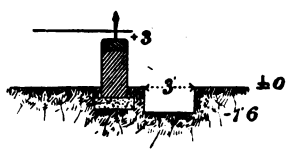


FIG.2.

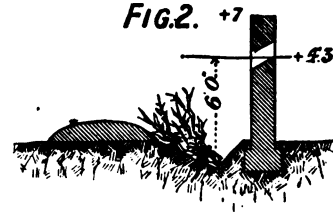


FIG 3

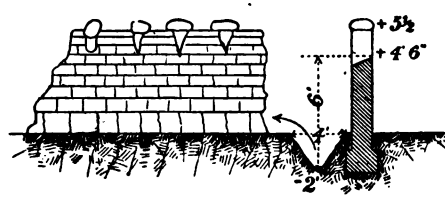


FIG.4.

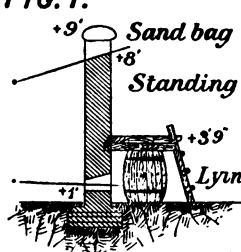


FIG.5.

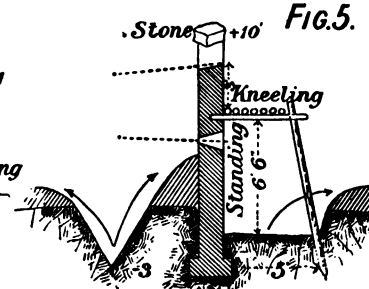
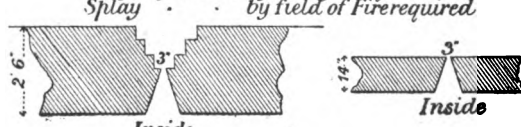


FIG.6.

LOOPHOLES.

Height governed by Range required
Splay · · by field of Fire required



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ditch in front, and will therefore require some time. (See Fig. 1, Plate XV.)

A wall 6 or 7 feet high may be prepared for defence in various ways:—

(*a*) It may be loopholed 4½ feet from the ground (Fig. 2, Plate XV.), and a small v-shaped ditch sunk on the outside.

(*b*) It may be notched along the top. (Fig. 3, Plate XV.)

(*c*) The men may fire over its top.

In this last case, a banquette must be thrown up for the men to stand on, and cover for them must be provided by means of sand-bags, stones, etc.

Walls 9 feet high and upwards can be prepared for a double tier of fire in various ways if required for flanking fire, one rank firing through loopholes near the foot of the wall, and a second through others or through notches, at the top. (Figs. 4 and 5, Plate XV.)

Loopholes.—The shape of loopholes is governed by the same general principles as explained in Chapter III. The smallest opening must be outside, as bullets will ricochet. A loophole in a brick wall will usually be begun by knocking out a header on the outside. At best it will be but a rough opening, but efforts should be made to make it as nearly to shape as possible. Picks and crowbars are the tools employed, and a fairly safe calculation is to allow one loophole to be made by one man in half an hour in moderately thick walls.

The interval between loopholes should not be less than about 3 ft., and would usually be 4 or 5 feet, to give men ample room to use their rifles.

Their position and direction will be regulated by the height of the wall, the slope of the ground in front of it, the direction in which fire is most required, and whether the men are to fire standing, kneeling, or lying down.

It is desirable to make the opening on the outside as small as possible, viz., about 3 or 4 inches wide. In a very thick wall, the narrowest part of the loophole will be in the centre of the wall, the splay outwards being notched to minimise the chance of bullets glancing in.

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The height over which men can fire has already been stated (see page 4). Remember men are generally firing at a considerable depression, and therefore *minimum* height must be given. The bottom of the loophole must allow for this depression. A height of 8 ins. will only be wanted for long ranges. At short ranges 4 in. will do.

Very thick walls and rubble masonry walls will generally have to be notched.

A *notch* only takes about 10 minutes to make. The top of it should be filled up by a sand-bag, large stone, etc. When men fire over the top of a wall, head cover of some sort should be provided for them if possible.

The shape, etc., of notches is governed by the same considerations as loopholes.

The most practical way of getting at the proper shape is to lay a rifle in the notch or loophole and see if you can use it.

Example 5.—The wall on Fig. 1, Plate XV. has to be prepared for defence in $\frac{3}{4}$ hour. What can be done?

This can be done by digging a small trench as indicated in the figure, men standing and firing over the top of the wall. The task is $3 \times 1\frac{1}{2} \times 5 = 22\frac{1}{2}$ cubic feet, and if ground is difficult the ditch would only be 2 ft. 6 in. or 2 ft. wide. The earth is scattered in rear.

The only way you could provide head cover in the time would be to notch the wall at the top and give additional cover with sand-bags or stones.

Example 6.—How many men would be required to prepare 50 yards of the wall shown in Fig. 3, Plate XV., for defence in one hour?

The area of the ditch section is about 4 sq. ft. Diggers at 7 ft. interval would have a task of 28 cubic feet.

$$\frac{150}{7} = 22 \text{ men.}$$

Each notch takes 1 man 10 minutes. Allow 5 notches per man in an hour. Thirty notches are required at 5 ft. intervals, so 6 men could do the notching. Total 28 men; say 30 men, 30 picks, 24 shovels for the work, or if crowbars are available, 24 picks, 24 shovels, 6 crowbars.

Example 7.—Eight feet of the wall shown in Fig. 4, Pl. XV., can be used to flank a long line of defended wall.

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How can it be prepared for defence so as to allow 4 men to fire from it?

The figure speaks for itself. The fire of 4 men is a great improvement on the 2 men that could only be fitted in with a single tier.

SANGARS.

Very often when it is impossible to dig, plenty of loose stones are lying about. Against an enemy without artillery walls of these may be rapidly built up, and give excellent cover.

Outposts and skirmishers will often find low stone walls, built in a horse-shoe shape so that men's legs get protection when lying down, the only way of quickly getting cover. Cover for the head can easily be got if *frontal fire* is sacrificed by putting a stone in front of your head and firing along and to one side of it.

EMBANKMENTS, CUTTINGS, ROADS, ETC.

Embankments, when parallel to the general front, often give good cover to supports and reserves; or if suitably placed, can be held by the shooting line itself, but offering such a distinct target to the enemy's artillery embankments cannot be considered good positions for the firing line. If an embankment is narrow and low, it may be occupied on the rear side (A, Fig 1, Pl. XVI.), but if wide, or high, the defenders must move forward to its front edge, throwing up a fire-trench on it, to obtain cover. (B, Fig 2, Pl. XVI.) If they did not do this, the ground for some distance beyond would be quite safe from their fire.

An embankment with all its advantages may have to be held for *tactical* reasons. As the depression would generally be very great to see the foot of a high embankment, some arrangement would have to be made to flank it. Probably short trenches for two to four men firing *along the embankment* and sited near the foot could in

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most cases be arranged. When exposed to artillery fire, and plenty of time and labour is available, the best scheme would probably be to hold both front and rear edges, with approaches cut across the bank to connect them. The rear edge may be stepped.

Cuttings may in the same way afford cover to supports and reserves, or be held by the shooting line. A cutting is generally along the slope of a hill with one side much higher than the other. If the defence is to be an active defence, it is right to hold the lower side of the cutting, as at A, Fig. 3, Pl. XVI., but in this case steps or paths must be cut up the rear slope, otherwise retreat from the position will be difficult. For a passive defence, the upper side of the cutting should be occupied as at B. The cutting, *if flanked*, will make a good obstacle. In some cases, both sides may be held with advantage, then the fire from above would cover the withdrawal from the lower position.

A *road* cut along the side of a hill, and bounded by hedges, may be treated as in Fig 4, Pl. XVI. Such a road would usually be conspicuous from a long way off, and would in most cases be avoided as a position for a firing line.

A *row of palings* might prove useful sometimes, either as a screen or revetment. (See Hedges and Figs. 3 and 4, Pl. XVI.)

Irregularities of ground, hollows, reverse slopes of hillocks, etc., often afford valuable cover to all the arms. It must of course be borne in mind that cover from view does not always mean cover from fire, and troops out of sight behind a reverse slope may suffer heavily from the enemy's distant fire, if the slope they are on happens to coincide with the trajectory of the projectiles. "Nevertheless, concealment from view must not be under-rated. The chances of being hit are so much less, and the enemy does not know whether his fire is effective or not." Possibly a reverse slope might be scarped to give more cover for reserves as in Fig. 5, Pl. XVI.

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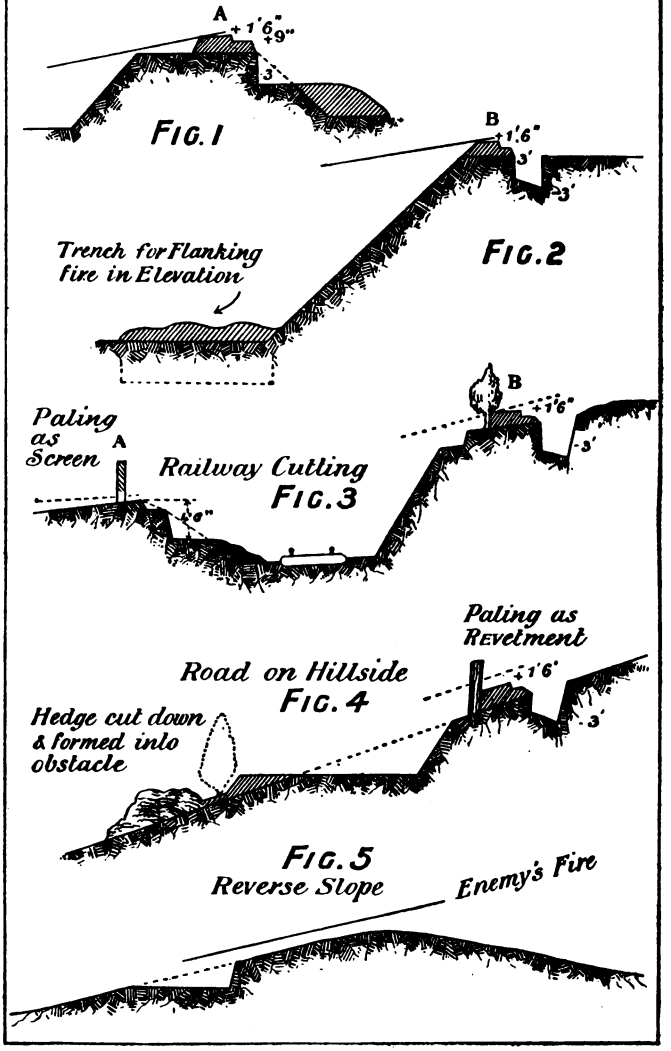
EMBANKMENTS.



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CHAPTER VIII.

STOCKADES AND BLOCKHOUSES.

Stockades are improvised bullet-proof walls. The remarks on the subject of walls apply equally to stockades. Being constructed almost entirely for passive defence, or for use against a savage foe, it is important to make loopholes as difficult as possible for the enemy to use.

Only small lengths of stockades for blockhouse walls, barricades, flanking walls, etc., will probably be used in civilised warfare.

Stockading is recommended:—

(*a*) When timber or railway plant is plentiful and close at hand.

(*b*) When artillery fire is not expected.

(*c*) When acting purely on the defensive.

The advantages of stockades are:—

1.—They are obstacle and parapet all in one.

2.—They give good cover and ample interior space.

3.—They must be breached before they can be captured.

The disadvantages are:—

1.—They are very laborious to construct.

2.—They are soon knocked to pieces by artillery.

Stockades were formerly most often made of timber alone; and against an enemy armed with a rifle of low penetration, such stockades may still be used.

As long as the present small bore bullet remains in use, no practicable quantity of timber, by itself, will make a bullet-proof stockade. The commonest forms of stockade consist of earth, gravel, or broken stone, etc., between two upright revetments of boards, or brushwood, canvas, corrugated iron, etc., between posts.

Plate XVII., Fig 1., shows an earth stockade. The earth is kept in by brushwood, planks, canvas, etc. This revetment is kept in by poles, held together at the tops

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and half-way down with wire which can be windlassed up. As it would be very hard to drive these thin poles, if 9 ft. long, small poles about 3 ft. 6 in. long, are driven about 1 ft. 6 in. into the ground, and the tops of these are lashed with wire in two places to the bottoms of poles, about 6 ft. 6 in. long.

Loopholes are governed as to shape by exactly the same general conditions as laid down in Chapter III.

They may be made of sand-bags, or by inserting plank boxes in the earth, gravel, etc. Loopholes can be cut out of corrugated iron and made into rough boxes.

When great lateral range is required, a loophole might be a continuous horizontal slit, the slit being formed by a plank on the top and another on the bottom with chocks of wood at intervals to support the top plank and the earth resting on it.

Fig. 2, Pl. XVII., shows a similar stockade made of corrugated iron, poles, wire, and shingle.

The advantage of shingle, road metal, coal, etc., for this class of work is apparent, as the saving in material needed, when compared with earth, is so great.

Figs. 3, 4, 5, Pl. XVII., suggest types of stockades that can be formed from railway material.

Fig. 4 could be made for two tiers of fire if required, as shown on Pl. XV., Figs. 4 and 5.

Against a savage foe armed with obsolete rifles, timber alone may give the necessary bullet-proof protection. Stockading in this case combining obstacle and parapet in one, forms a most useful defence. The material of the country will have to be used, and it will be necessary to experiment for yourself to find out what thickness is required. The great point in this class of work is to remember that savages generally have a strong element of fanaticism, and you want a strong obstacle *quite close* in case of rushes at night, and also to prevent the enemy from getting close under your loopholes, and using them against yourself.

Figs. 1 and 2, Pl. XVIII., show how bamboo can be used for stockades, a most formidable obstacle in each case being provided out of sharpened bamboos.

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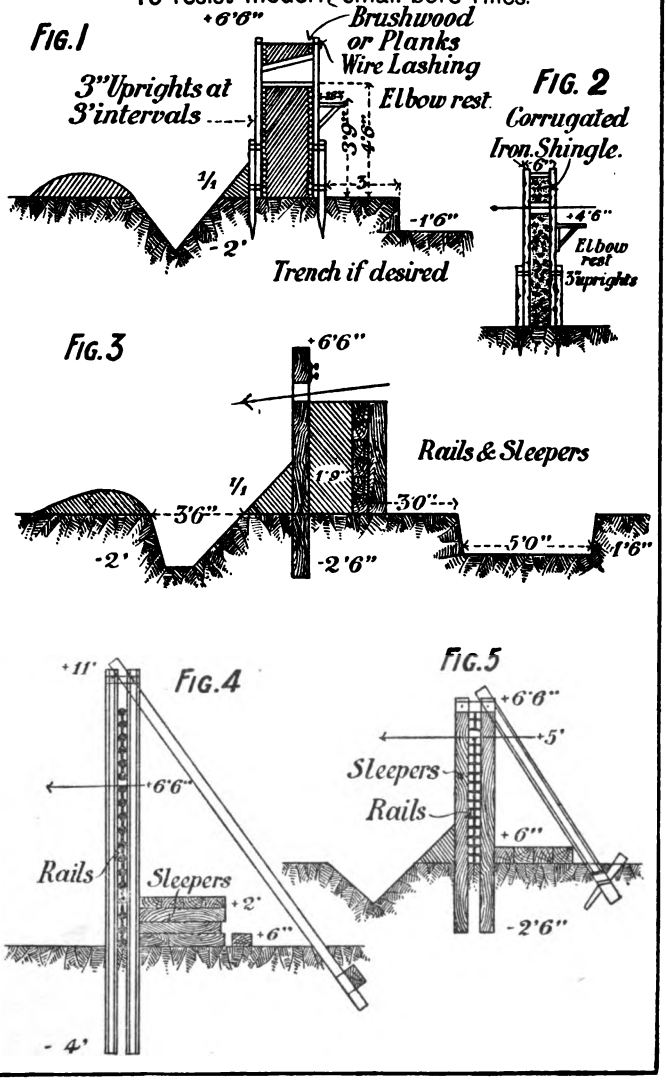
STOCKADES

To resist modern small-bore rifles.



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STOCKADES AGAINST SAVAGES.

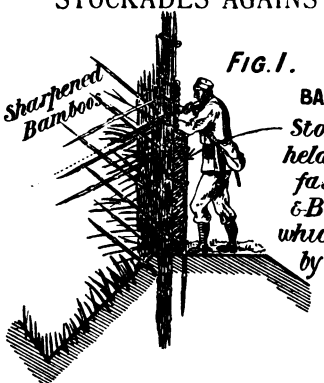


FIG. 1.

BAMBOO STOCKADE

Stones & Earth held in between front fascine of Bamboo & Bamboos in rear which are tied together by lashings of Bamboo

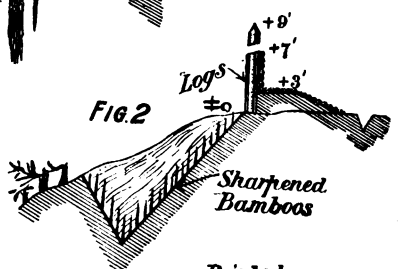
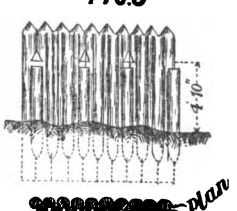


FIG. 2

FIG. 3



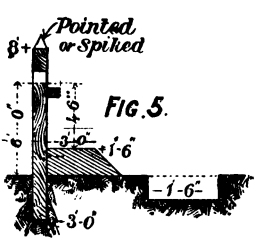


FIG. 5.

FIG. 4.

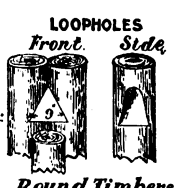
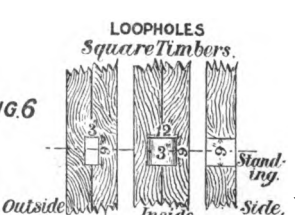


FIG. 6



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Figs 3, 4, 5, and 6, are types of stockades and loopholes for square and round timbers.

BLOCKHOUSES.

A blockhouse is practically a closed stockade with a roof, giving shelter from the weather.

It is almost impossible to design blockhouses that can resist artillery.

The roof may be required in some cases, when the blockhouse is commanded by high ground, to give protection against descending rifle bullets and in very mountainous countries might be required to be actually directly bullet-proof.

The ordinary type of blockhouse would be any form of bullet-proof wall available, surmounted with a light *weather-proof* roof or a small closed breastwork of earth with a tent in the middle. A shed could quickly be turned into a blockhouse by building up sand-bags against the walls, etc.

Blockhouses may be used for the protection of piquets guarding mountain roads, culverts, and other vulnerable points on a line of railway, or bridges or fords, where guns are not likely to be used against them.

A good obstacle round a blockhouse is required, especially for night, and, if possible, some means of illuminating it. Blockhouses should be well stored with water, ammunition and provisions, and a latrine outside with a trench leading to it will be required.

In South Africa many types of blockhouses were employed, and a vast system of blockhouse lines, consisting of blockhouses at intervals with a wire fence between, was employed at the close of the war, when the Boers had no more artillery. Corrugated iron and stones somewhat similar to Fig. 2, Pl. XVII., was a common form of wall. Large numbers of circular blockhouses were used, which were made up at a depôt and sent by train to the site required. The parts were all made to a standard pattern, and the whole structure could be easily erected by half a dozen skilled men in 2 days.

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Occasionally double storied blockhouses may be found useful, and it will be sometimes advisable to put the upper storey diagonally over the lower one, distributing the fire equally all round, and also forming machicoulis galleries flanking the lower storey.

It will be a good thing to surround a blockhouse, if possible, with a fire trench. By this means—

(*a*) The garrison are not confined to the blockhouse, and can take the air without being sniped.

(*b*) It will be possible to hold the blockhouse even if artillery is brought against it.

Fig. 1, Pl. XIX., shows a section of a circular blockhouse made of earth and planking surrounded by a fire trench. Entrance is gained by a passage from the fire trench under the blockhouse wall. The obstacle round the blockhouse is not shown in the figure.

Fig. 2, Pl. XIX., shows a two-storied blockhouse against a railway embankment.

To defend a bridge would very often require *two* such blockhouses on opposite sides of the embankment and bridge, owing to the impossibility of covering all the ground from one blockhouse.

Fig. 3, Pl. XIX., shows two blockhouses connected by a wire fence. The blockhouses fire along the fence, but not into each other.

TAMBOURS.

A *tambour* is a stockaded, loopholed enclosure, built outside against a line of wall or stockade, sometimes at an angle of it, and communicating with the interior by a doorway, window, or a hole broken through the wall. By constructing it at an angle, one tambour can flank two sides. It can be open overhead, but it is better roofed in, so as to be weatherproof, and can be arranged (if the material is available, and the post an important one) for a double tier of fire.

Figs. 4 and 5, Pl. XIX., show a tambour of the smallest size for 2 men.

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BLOCK HOUSES.

FIG. 1.

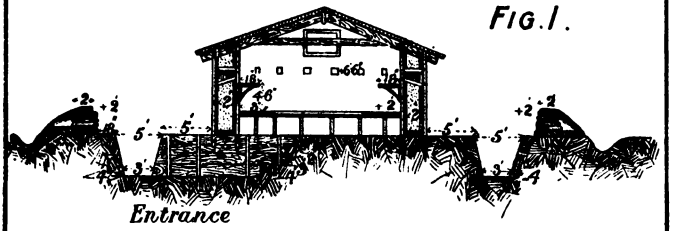


FIG. 2.

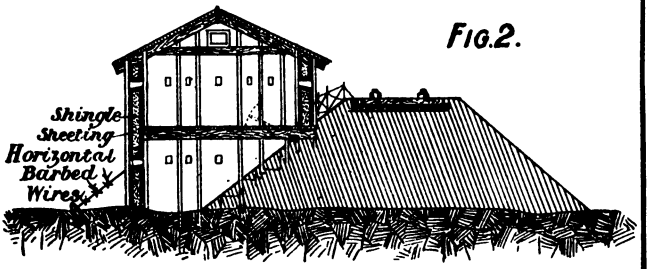


FIG. 3.

FIG. 4.

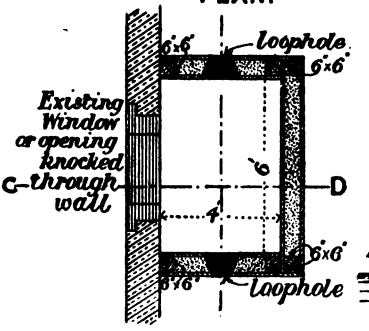
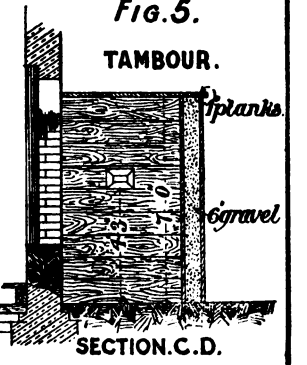


FIG. 5.



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CHAPTER IX.

OBSTACLES.

Obstacles are intended to increase the difficulties of the enemy's attack. They achieve this by retarding his progress as he advances to the assault, by breaking up his formations, and by detaining him under fire while he endeavours to pass, or remove them. To some extent also, they define the lines of attack by which he must advance, and thus enable preparations to be made to meet him with some degree of certainty.

Against a rush of savages an obstacle is essential to give the stopping powers of the rifle a full chance. Isolated posts for passive defence are greatly strengthened by a good obstacle, and if liable to be raided at night an obstacle is essential.

In the defence of a position, obstacles are particularly valuable in a *close country*, because there an enemy, availing himself of the existing cover (banks, hedges, etc.), may get close up to you with comparatively small loss. It is, therefore, all the more important to stop him under a heavy fire by an array of obstacles in the last 200 or 300 yards.

At night it is very hard to see, even when bright moonlight, more than about 200 yards. In small posts, etc., the obstacle wants to be quite close, and, if possible, illuminated.

It will often be possible to ensure the fire being directed on the obstacle at night by making fixed rifle rests, bars across loopholes, etc., etc. If these are experimented with by day and made accurate, they will prove exceedingly valuable in night attacks.

By the expenditure of a little labour and ingenuity, natural features may often be converted into formidable obstacles: *e.g.*, steep places may be made steeper; deep holes, or cuts, may be made in shallow water; inunda-

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tions may be formed, etc., etc. These natural obstacles can generally be taken in hand when clearing.

In good obstacles, the following conditions are desirable:—

1.—They should be under the close fire of the defenders, within 300 yards, and for night work within 50 yards, unless the obstacle can be effectually lit up.

2.—They should give no cover to an assailant.

3.—They should not be liable to serious damage from the enemy's artillery fire.

4.—They should be difficult to remove, and, if possible, should require special tools for that purpose.

5.—They should be so placed that their exact position may be unknown to the attacking force.

In a position there will generally be sections favourable to counter attack. These sections will be kept fairly free from obstacles. In the sections unfavourable to counter attack, a more passive defence can be relied upon, and the use of obstacles will mean a saving of men needed to defend these sections, and increase the number of reserves.

The various obstacles generally used are described below.

ABATIS.

Abatis is laborious to construct unless the trees are on the spot, the labour of dragging the trees with their branches on being very heavy. When clearing woods, etc., making a very rough abatis will be the best way of disposing of the cleared stuff. (See Chap. VI.)

To make abatis carefully, at least 6 hours and a strong working party are required, so that very little of it can be undertaken in hastily fortified positions.

Abatis consists of stout branches of trees about 15 ft. long, laid in a row, fully breast high, close together, pointing towards the enemy. Small twigs and leaves are trimmed off, and the larger branches pointed. The butts

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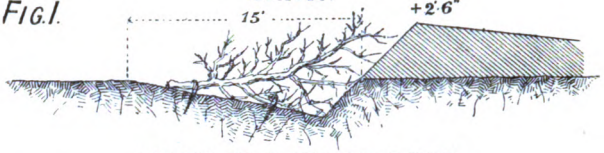
OBSTACLES.

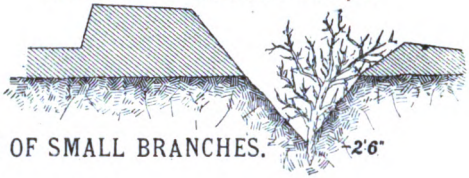
ABATIS.

FIG.1.



ABATIS IN V SHAPED DITCH.

FIG.2.



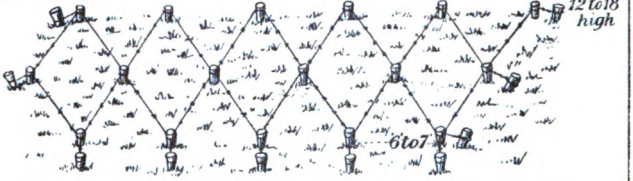
ABATIS OF SMALL BRANCHES.

FIG3.

Excavated earth replaced and rammed down.

LOW WIRE ENTANGLEMENT.

FIG.4.



HIGH WIRE ENTANGLEMENT.

FIG.5.

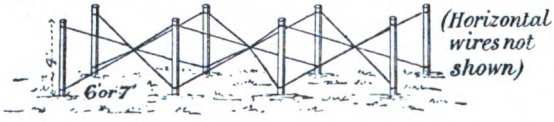
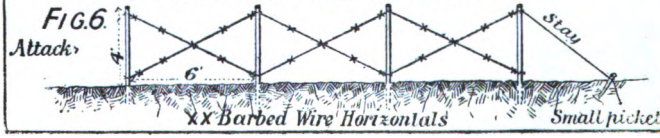


FIG.6.



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are securely fastened to the ground with pickets, rope, etc., or else lashed to logs laid across them. The broader the belt of abatis the greater the obstacle. If only small branches are available for it, at least 2 or 3 rows should be put down.

Barbed wire mixed with abatis greatly improves it.

Generally in hastily fortified positions there will be no time to make careful abatis. All that can be done will be to drag the trees to the best position for abatis, picket them down, mix barbed wire if available with the trees, and trim off the small stuff to prevent the abatis spoiling the field of fire. About a man to every 4 yds. of abatis in one row would be a fair estimate for a four hour relief at this kind of rough abatis. The felling and carrying parties must be reckoned separately.

Example 1.—In the cherry orchard in Example 3, Chapter VI., it is required to make 2 rows of abatis 100 yards long. 4 hours are available. What men and tools will be required?

In Example 3 we have already allowed a large party to drag the trees in addition to the men cutting them down. These men will drag the trees to the abatis position.

2 rows of 100 yds. = 200 yds. = 50 men to make the abatis.

Tools: A bill-hook or hand-axe each (some saws if available), 5 pliers, 5 mauls, barbed wire (if available), say 10 strands each row = 20 × 100 = 2,000 yds.

Some examples of abatis are shown on Pl. XX.

Fig. 1 shows an abatis placed in advance of a work and covered by a glacis.

Fig. 2.—An abatis at the bottom of a ditch, the branches placed vertically.

Fig. 3.—The method of forming an abatis from small branches.

20 men can complete an abatis (similar to Fig. 1, but without any excavation) in two rows 30 yards long in 6 hours, the trees being small and quite close.

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TREE ENTANGLEMENTS, Etc.

This class of entanglement has already been referred to when speaking of hedges. It is formed simply by cutting trees, brushwood, etc., half through, about 3 ft. from the ground, pulling the upper parts over, interlacing them and picketting them to the ground. Large trees thus treated form almost insurmountable obstacles, specially useful for blocking roads or the near edges of woods from which the enemy may be expected to issue. Vines and hops treated in this way form excellent entanglements. Barbed wire greatly improves this obstacle.

Example 2.—The edge of a wood 300 yds. long is to be quickly turned into an obstacle. The trees are roughly 6 in. diameter and about 4 yds. apart. What can 75 men with a cutting tool each do in 4 hours?

A 6 in. tree will only take at most 10 minutes to pull over. If, therefore, each man prepares one tree a very good show ought to be made in the 4 hours, as a man can do 4 yds. as in Example 1.

With, say, 3,000 yds. of barbed wire, an excellent obstacle could be made.

WIRE ENTANGLEMENTS.

Wire entanglement is the best of all obstacles, because it is easily and quickly made, difficult to destroy, and offers no obstruction to view. The materials are portable and are often found on the site.

Wire may be used in many ways, of which the following are a few:—

(*a*) As a trip, wire stretched just above the ground.
(*b*) As a simple fence, causing delay and confusion at night.
(*c*) As a concealed obstacle in a ford.
(*d*) As an adjunct to a tree entanglement.
(*e*) As a wire entanglement.

Barbed wire should always be used for horizontals, if available.

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Low wire entanglements are made by twisting wire round stout stakes driven into the ground chequer-wise in rows about 6 ft apart. The wire is taken diagonally across from stake to stake, about 18 in. from the ground, and the entanglement is finished off by a wire run horizontally along the top of each row of stakes. The outside pickets should have wire stays. (Fig 4, Pl. XX.) This kind of entanglement should be at least 10 yds. deep, and, if possible, laid down in long grass, or under water, etc., where it is not noticed. Its advantages are that the materials for it are very portable, it is quickly put up, almost indestructible, and impassable by cavalry. It is not nearly so formidable an obstacle as high wire entanglement.

Ten men will entangle a piece of ground 50 yards by 10 yds. in 5 hours, or 1 man can do 10 sq. yds. in 1 hour. Materials required: 3 bill-hooks, 1 mallet, 2 pliers, 150 stakes, and 1,500 yards of wire.

Another form of entanglement is shown in Fig. 5, Pl. XX. In this case the stakes are 4 ft. high, and planted about 6 ft. apart. The wire is taken from the head of one stake to the foot of the one diagonally opposite to it, and so on; and these diagonal wires are afterwards connected with horizontal wires, the whole forming a network most difficult to cross.

Barbed wire horizontals and the remainder plain wire is a common form of high wire entanglement. (See Fig. 6, Pl. XX.)

Organise in parties of 10 men, as in case of low wire, and allow same tools, except that 2 mauls are needed in place of 1 mallet.

Low wire requires 1 ft. of wire per square foot of entanglement.

Another and practical form of high wire entanglement is constructed by driving in posts of different lengths at about 6 ft. to 8 ft. apart, but quite irregularly. See rough plan, Fig. 3, Pl. XXI. No accurate measurements are necessary.

The posts or pickets should be at least 18 in. in the ground, and may vary from 4 ft. to 6 ft. in length, and

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the wire is indiscriminately taken from the tops to the bottoms of neighbouring posts, after which horizontal wires (barbed, if possible) are laid along the obstacle. The inner line of posts should be very strongly anchored down to prevent the enemy removing it easily with grappling irons and ropes.

Assuming that material is on the spot, 5 men can construct 40 sq. yds. in four hours.

High wire requires 5 feet of wire per square foot of entanglement, and takes 3 or 4 times as long to make as low wire. If all barbed wire is used the entanglement will take twice as long to make as with plain wire.

All wire entanglements, as described in the Text Books, are only intended as *types*.

There would rarely be time and material to make high wire entanglements on a large scale. When the defenders are few in number and an extra good obstacle is necessary, high wire would be a very useful type.

An excellent entanglement on the lines of high wire can be improvised of hops. Orchards left standing in the field of fire may have trees utilised as pickets, etc.

Plate XXI., Figs. 1 and 2, show how an ordinary wire fence may be converted into an obstacle by putting aprons or stays on the posts and running barbed wire horizontals along the stays. With everything ready on the spot a man might do 10 yards linear in 4 hours. Each party of 10 men would require 2 pliers, 2 bill-hooks, and 1 maul.

This type of obstacle was largely used on the blockhouse lines in the South African War. A ditch on each side was sometimes added to prevent wheeled transport getting through the fence when cut.

Trip wires can be arranged in most forms of wire entanglement, running loose through staples in the pickets. With barbed wire, care must be taken that the barbs do not foul the staples. Such trip wires should be just within the front edge of the entanglement so as only to be moved by anyone actually trying to cross the entanglement.

Trip wires, as above, may be used to set off various types of automatic alarms, such as spring guns, rails

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falling on a nail in contact with the cap of a cartridge, etc. Wires may be arranged like trip wires, but giving an alarm when the wire is cut; this is easily done by using a big stone or a rail as a counter-weight.

In defences, where the garrison has plenty of time to get into the working of these automatic alarms, which require a great amount of ingenuity to make them effective, they may be tried with great success.

Tin cans, filled with stones, hung on the wires at intervals, are a very simple and effective automatic alarm.

If it can be arranged it will be very useful to light up obstacles at night. In an enclosed work, care must be taken in lighting up the obstacles for one face not to mask another face, as one cannot see *through* a light. This can be easily prevented by screening such means of illumination so that it interferes with no other part of the defence.

The automatic alarms may sometimes be used to ignite flare lights, *e.g.*, a rail, released by a trip wire or cutting a loose wire, falls on a nail touching the cap of an empty cartridge. This cap sets off an instantaneous fuze inserted in the cartridge with its other end in a small bag of gunpowder or flaked up dry gun-cotton (N.B., cordite is uncertain). The powder, etc., lights a heap of shavings, dry cotton waste and powdered resin, etc., etc., which give a bright flare that sets fire to a large quantity of inflammable material soaked in paraffin, etc.

So many means can be improvised of effecting some simple form of automatic alarm that a detailed description of any one is hardly necessary. As before pointed out, considerable ingenuity is required to make them a success, and the wire, if in long lengths, will generally have to be kept very taut. Unless they are fairly certain in their action, there is little to choose between them and the tin cans hung on the wire, which is the essence of simplicity.

For roughly estimating the lengths of the different kinds of wire entanglements which can be constructed under varying circumstances, the following may be taken as a guide, assuming that the material is available on the spot.

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	Frontage.	Average Width.	No. of Men.	Time.	Amount of Wire.
Low Wire	20 yds.	9 yds.	10	2 hours.	1 ft. per sq. ft.
High Wire ... ... See Fig. 6, Pl. XX.	8 yds.	6 yds.	10	2 hours.	5 ft. ,, ,,
High Wire ... ... (Irregular) See Fig. 3, Pl. XXI.	10 yds.	4 yds.	10	2 hours.	5 ft. ,, ,,
Wire Fence... (South African) Without Fence available.	25 yds.	3 yds.	10	2 hours.	15 yds. per yard of frontage.

It is useful for practical work to know the approximate weights of wire suitable for entanglements, as very often transport has to be requisitioned. The weights given below are the weight of a length of 1 mile:—

No. 6 S.W.G. wire, a thick strong wire, hard to cut with pliers ... ... $5\frac{1}{2}$ cwt.

No. 14 S.W.G. wire (barbed), ordinary barbed wire ... ... $2\frac{1}{2}$ cwt.

No. 14 S.W.G. wire, plain wire for stays, etc. ... ... 1 cwt.

No. 19 S.W.G. wire, thin wire for binding horizontals to stays, etc... ... $\frac{1}{4}$ cwt.

The following examples show how calculations for wire entanglements can be thought out:—

Example 3.—How much wire will be required to entangle a strip of ground 100 yards by 10 yards, using small stakes? How many men could do this in 1 hour?

100 yds. by 10 yds. = 1,000 sq. yds. = 9,000 sq. ft.

Therefore, 9,000 feet, or 3,000 yds. of wire will be required, say 2 miles.

100 men, with 10 lots of tools as laid down for each party of 10, would be required, and 300 stakes, 2 ft. 6 in. long.

Example 4.—How much barbed wire would be required for 100 yards of entanglement as Fig. 6, Plate XX?

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There are 9 strands 1st bay.
,, 7 ,, 2nd bay.
,, 7 ,, 3rd bay.

23 strands.

23 × 100 = 2,300 yds. of barbed wire will be required, say 1½ miles.

Example 5.—How much plain wire will be wanted in Example 4? How many men will be required to make the entanglement in 4 hours?

100 yds. × 6 yds. = 600 sq. yds.
,, ,, = 5,400 sq. ft.
,, ,, = $\frac{5{,}400 \times 5}{3}$ yds. of wire
= 9,000 yds. of wire.

2,300 of this is barbed (Example 4), so 6,700 yds. plain wire is required, say 4 miles.

5 ft. pickets are 2 yds. apart, so we shall require a picket for every 4 sq. yds., or 150 5ft. pickets are required.

Small pickets for stays, say 1 ft. 6 in. long. One every 2 yds. run on each side, *i.e.*, one per yard, or 100 + 8 at the ends = 108 small pickets, say 120.

10 men do 8 yds. frontage in 2 hours.
10 men do 16 yds. frontage in 4 hours.

Therefore for 100 yds. frontage it would be advisable to detail 7 parties of 10 men each, with tools for each party of 10 as laid down.

Example 6.—What material and working party is required to make ¼ mile of the fence shown in Figs. 1 and 2, Plate XXI., in 4 hours?

Assuming that there is no fence already available and that the posts or pickets are on the spot but have to be prepared, etc., then 10 men construct 50 yds. in 4 hours. Therefore, constructing ¼ mile there will be required 9 parties of 10 men each, the tools for each party being 2 pliers, 2 bill-hooks, and 1 maul.

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Wire.—15 yards × 440 yards = 8,600 yards.
= 5 miles say.

Posts.—One every 4 yards.
∴ 5 ft. or 6 ft. posts = $\frac{440}{4}$ = 110.

Binding wire and small pickets are also useful.

FOUGASSES.

Fougasses are inclined holes dug in the ground, with a charge of explosives placed at the bottom, and loaded with stones, brickbats, or live shells. They can be fired either by fuze or electricity, and are useful for defence of defiles, against boat landings, etc. See Fig. 1, Plate XXII.

PALISADES AND FRAISES.

Palisades would principally come in useful for savage warfare. They are stout palings, strengthened by ribands top and bottom, made of logs, 3 or 4 in. apart, triangular in section (each being 7 or 8 in.) and about 10 ft. long (Fig. 4, Plate XXI.). They are planted upright in the ditch of a work (3 ft. in the ground and 7 ft. out) at the foot of the counterscarp, the ditch in rear being deepened, and made v-shaped, to prevent an enemy forming up in it, or else planted all over with sharp stakes. They are also often used to close the gorge of a work, or in any position not exposed to artillery fire. A quick way of putting up palisades is to dig a narrow trench for them first, 3 ft. deep: then prepare and plant them in panels of 9 or 10 posts each, filling in the trench with earth well rammed.

Fraises are simply palisades planted in the escarp, or counterscarp of the ditch, in a nearly horizontal position. (Figs. 5 and 6, Plate XXI.) About half their length is buried in the earth, and half projects over the ditch. Thus they are only applicable to *wide* ditches. They should be laid ridges uppermost to increase the difficulty of standing on them, and must be strong enough to prevent an enemy breaking them down by sheer weight. If used on the escarp side, they are sloped slightly down-

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FIG. 1 WIRE FENCE (South African)

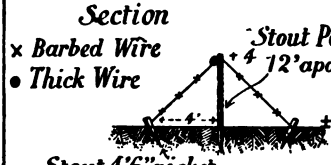
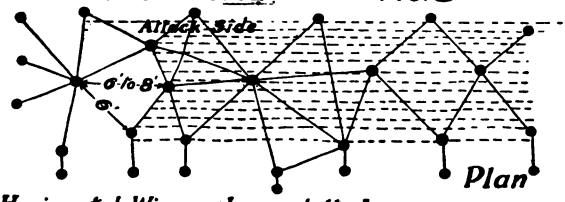


FIG. 2

HIGH WIRE

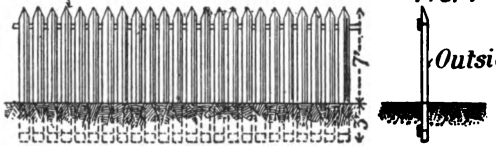
FIG. 3



Horizontal Wires shewn dotted
Posts at irregular intervals & varying lengths.

Posts about 4" apart

FIG. 4



FRAISES

FIG. 5

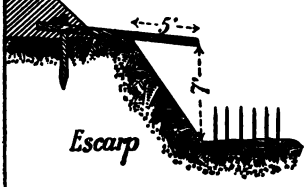


FIG. 6

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wards, so as not to catch hand-grenades, etc., thrown over by the garrison, but their points must in any case be 7 ft. clear from the bottom of the ditch, or men may catch hold of them and help themselves up.

When used on the counterscarp side, they are given a slight cant upwards, to increase the drop from them into the ditch. Pointed stakes may with advantage be planted all along the bottom of the ditch when fraises are used.

INUNDATIONS.

An inundation is formed by damming a stream so that the water collects in one place. To be unfordable, it should be 5 ft. deep in its shallowest part, and as it will rarely be practicable to construct a dam that will retain a greater depth than 10 ft. of water in the deepest part, it is evident that the configuration of the ground must be very favourable to make it worth while to attempt an inundation that shall be formidable in its dimensions. The most favourable position will be where the bed of the stream has only a slight fall, and the sides of the valley rise regularly and rather rapidly. The maximum practicable height of the dam being assumed, its length, and the consequent breadth of the inundation, will depend on the slope of the sides of the valley. The length of the inundation will depend on the fall, or slope of the valley itself.

When it is evident that only a shallow inundation of 2 ft. or 3 ft. is feasible, an efficient obstacle may be formed of it by digging pits and trenches in the ground before flooding it, and spreading crows' feet, harrows, and other impediments over it.

The thickness of a dam at the top should be equal to the depth of water retained by it. Its slopes are:—

Up-stream, usually $\frac{1}{2}$: the other way 1 in 1.

The soil of the dam should be of puddle clay, and well rammed.

A waste-weir is always necessary to carry off the water of the stream. If possible, a channel for it should be cut in the solid ground clear of the dam. If not possible, it

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must be in the dam itself. It must be well revetted, and its surface must be 2 ft. or 3 ft. below that of the dam. A regular big inundation would rarely come within the scope of field operations, but occasionally an opportunity for something of the kind might occur; as, for instance, when an embankment crosses a valley, when by blocking up the arches of the bridge in its centre an efficient inundation might be formed with comparatively little labour.

BARRICADES.

Barricades are used in the defence of streets, bridges, etc. They can be made of almost anything at hand, trees, furniture, carts, etc., but they must be constructed of earth if they are likely to be battered by artillery. Banquettes must be provided so that the defenders can fire over them, and they must be flanked in front and rear by loophole from the adjacent houses. The houses down both sides of the streets should be barricaded, and loopholed, and communication broken through the walls from one to the other, so that fire may be kept up from them on the advancing column, and yet the retreat of the flanking parties secured. Passages through a barricade, or round one end of it, are generally required. These can be arranged for by building the barricade in two parts overlapping each other, or by constructing it at a point where a house stands back somewhat from the general alignment, and affords a good fire on the passage round it. These passages can be temporarily closed by chevaux-de-frise, etc. (Figs. 2, 3, Plate XXII.)

MISCELLANEOUS OBSTACLES.

The Gabion trip.—The bands of Jones' iron-band gabions, hoops of barrels, etc., form a fair obstacle, especially against cavalry, if they are buttoned up, and laid on the ground like hoops in parallel rows, and arranged chequer-wise, about 3 or 4 ft. apart. Each band should be connected by wire, to the one next to it, and the rows

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FOUGASSE

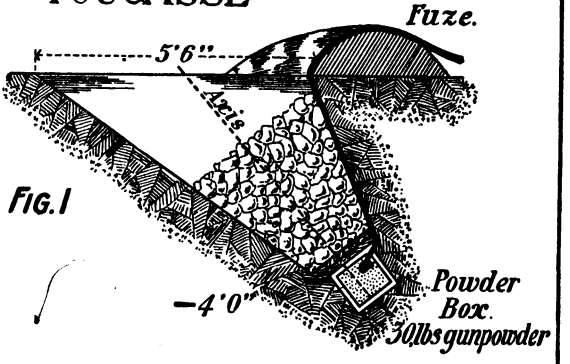

FIG. I

BARRICADES.

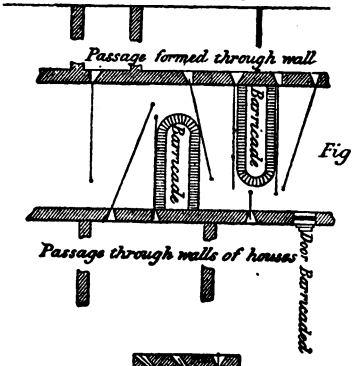

Fig 2.

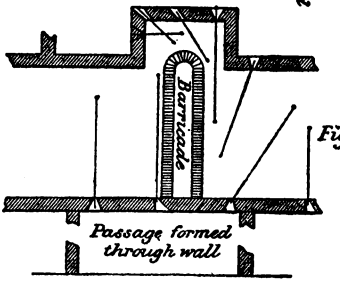

Fig. 3.

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can be picketed here and there to prevent them being removed.

Crows' feet are formed of 4 iron spikes, about 3 inches long, welded together in such a way that however thrown, will always point upwards. They are useful against cavalry, and may be placed with effect in fords, etc.

Pointed stakes.—The small branches cut from abatis, bamboos, etc., may be utilised to make pointed stakes. They are driven firmly into the ground till only 1 or 2 ft. project and then sharply pointed.

Improvised obstacles include iron railing, or fencing; broken bottles and glass; harrows, buried with only the spikes exposed; broken cart-wheels, etc.

SURMOUNTING OBSTACLES.

Obstacles may be passed by either breaking through or by climbing over them. Cutting through entails a fairly long halt by the attackers, and losses may be heavier than if the obstacle were passed over; but a passage once cleared is much more effective for the attack.

Ditches.—The passage of a ditch may be facilitated by the assaulting columns bringing up with them ladders, sacks of wood, shavings, etc.; or bundles of hay, or straw; or fascines cut up into convenient 6 ft. lengths, etc., etc.

Abatis, if green, is most difficult to destroy, and artillery fire has little effect upon it. The only way is to attack the butt fastenings with axes, etc., and then try and draw aside some of the branches, but it would be very hard to do this under fire. Gaps may be made in it by means of gun-cotton; and if dry, it may be set on fire. Gun-cotton may often be effectively thrown by hand. It should be tied up in bundles of 4 or 5 slabs, with the holes for the primers vertically over one another. A 1 oz. primer, with a No. 8 detonator, is arranged so that the top of the detonator is below the top of the gun-cotton. The detonator is thus protected from any accidental blow which might cause premature explosion.

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Palisades and *fraises* may be blown down with powder or gun-cotton, or demolished with axes, etc., if the flanking fire protecting them has been subdued, or lastly they may be surmounted by ladders.

Artillery has little effect on *wire entanglements*. The crater formed by high explosive shell rather improves the obstacle than otherwise. A charge of 6 lbs. of gun-cotton made up as above will clear the wire between 4 posts of high wire entanglement. Good cutting pliers are of course most useful.

Wire entanglements may be surmounted by making roadways over them with hurdles, planks, doors, etc., or with rough ladders, 12 to 15 ft. long, with steps made of pieces of plank about 9 in. wide and 2 ft. 6 in. apart from centre to centre.

If the entanglement is made irregular and with pickets of varying heights, it will not be so easily crossed with ladders.

A party sent out to remove obstacles should always carry hand-saws, axes, bill-hooks, cutting pliers, and generally explosives.

Grapnels with ropes 30 or 40 yards long are most effective in removing wire entanglements if plenty of men are available. The grapnel is thrown over the entanglement and with 20 or 30 men on the rope there are few entanglements that cannot be walked away with.

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CHAPTER X.

DEFENCE OF VILLAGES, HOUSES, AND WOODS.

A village may be occupied and held:—

(*a*) As a point in the main line.
(*b*) As an advanced post.
(*c*) As a reserve post.
(*d*) As a detached post on a line of communications.

The advantages of occupying a village are:—

(*a*) It can generally be made quickly defensible, and admits of a protracted and obstinate defence.
(*b*) The numbers and disposition of the garrison, and of troops in rear, are concealed from the enemy's view; and often good cover is afforded against his fire.
(*c*) The troops get shelter from the weather.

The disadvantages are:—

(*a*) Scattering of the garrison, and consequent difficulty of supervision.
(*b*) Liability to loss from splinters, falling houses, etc.

In the days of common shell, with a bursting charge of powder, houses were easily set on fire. Shrapnel and high explosive shell have little incendiary effect.

The necessity of defending a village is generally settled by *tactical* reasons. As far as fortification is concerned the village has to be defended in the best way the resources and time available permit. Some villages are much easier to defend than others. The measures taken for defence depend:—

1.—Upon the form and nature of the surrounding ground.
2.—Upon the shape of the village, and the nature of the houses, etc.

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The surrounding country affects the question of defence in many ways, *e.g.*:—

(i) Are there positions commanding the village within effective artillery range?

(ii) Will the environs give a good natural field of fire without it being necessary to undertake extensive clearings or demolitions.

(iii) Can a counter-attack be made round the flanks of the village?

The nature of the houses greatly affects the manner of utilising them for defence, and the precautions to be taken to avoid fire.

With reference to the shape of villages, there are three common types, the *circular*, the *salient*, and the *broadside*.

The circular form is strong all round and suitable for any position.

The salient—that is a straggling village, houses chiefly on either side of a main road, end-on towards the enemy—is easily raked by the enemy's fire, and requires much artificial addition in the shape of shelter trenches, etc., thrown out towards the flanks, to increase the front of fire. On the other hand, it admits of an obstinate house to house defence, and is very strong against a flank attack. It may be necessary to abandon the advanced portions of such a village, and demolish as far as possible any cover they provide for the enemy.

The broadside type is the same description of village as the salient, but slewed round as it were, so as to be broadside on to the enemy. This type is very strong in front, and safer from the effects of fire, but it requires attention on the flanks.

To what extent a village should be fortified depends upon the circumstances under which it is held.

If occupied as a pivot in the main line of defence, it should be strongly fortified in front and on the flanks.

If held as an advanced post, its distance from the main line will chiefly determine to what extent it is to be

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defended, and consequently how much of its perimeter need be fortified.

If held as a reserve, or detached post, an obstinate defence all round is sure to be required, and it must be fortified accordingly.

ARRANGEMENTS FOR THE DEFENCE OF A VILLAGE IN THE FRONT LINE OF A POSITION.

General principles.—The fate of many large battles has been dependent on the capture of a village. The facilities for *obstinate defence* should be utilised to the full, and it should be remembered that even if the enemy has got a footing in the village a few defended houses may still give sufficient resistance to enable reinforcements to come up and expel the enemy before he has been able to establish himself. Villages have generally fallen through well-directed flank attacks.

To make the most out of a village it is therefore important:—

(i) To have a strong *main* line of defence.

(ii) To make the most of the houses for obstinate defence by forming a second line of defence mostly of defended houses, and preparing especially strong houses for obstinate defence to the last.

(iii) To pay particular attention to the flanks.

(iv) To have good and easy communication everywhere, so as to ensure the prompt action of reserves when wanted, and the orderly retirement of the whole when necessary behind the second line.

Garrison.—The troops should be told off to particular sections of the village by complete companies, etc., as required, and each party should fortify, and be responsible for, its own section. The sections must have clearly defined natural boundaries, especial attention being taken to leave no doubt as to what section roads leading to the front are in. Each section will have its own main

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line and second line. Sometimes the second line may be the supports to the first line.

The *main line* will take advantage of all the natural cover that exists. The principles of the preceding chapters have merely to be applied.

The *second line* will, as far as the time and resources available allow, take advantage of the houses for an obstinate defence. If the village is exposed to artillery fire it will often be advisable to leave houses standing in front of those prepared for defence to act as a screen. The second line can be under cover from artillery fire behind houses or in trenches.

In addition to the above there will be a *general reserve* for the village which provides garrisons for the *keeps*, and will be kept in the village or in the rear of it ready to make counter-attacks, or reinforce any hard pressed section as required.

The main consideration is a *powerful frontal fire on the principal lines of attack.*

The garrison, of course, will vary considerably, but 1½—3 men per yard (including reserves) of the perimeter to be defended is a fair general estimate. Generally at least two-thirds will be in the main line and its supports.

Guns are best on the flanks or on high ground in rear, as placing guns in a village generally impairs their mobility. On the flanks they can bring an effective cross-fire over the front of attack.

Machine guns can be used with great advantage behind barricades to sweep long broad streets.

Miscellaneous precautions.—The field of fire all round must be well cleared of everything that could afford an enemy cover, and obstacles must be freely used at weak points. Roads should be barricaded at their entrance into the village, and the adjacent houses loopholed and prepared for defence. Communications will require great attention, trifling matters (apparently), such as breaking a gap through a wall, levelling a bank, or filling up a ditch, being often of vital importance. Sign posts will be most useful. Measures for extinguishing fires that may break out must be provided.

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In the second line it will be very difficult to get much clear space in front, so the fighting will be almost hand to hand, and a close flanking fire more than ever valuable.

Keeps.—A house selected for a keep should have thick walls, and a flanked outline. It should be out of sight of the enemy from a distance if possible, and sheltered by surrounding buildings from distant artillery fire. It has a separate garrison of its own, who must try and hold out till assistance arrives. No communications must pass through the keep.

Finally the arrangements for the defence in the order of relative importance, are:—

1.—Organise the sections of defence and allot the troops to them.
2.—Making a rough position for firing line and clearing a field of fire, making rough obstacles while doing so.
3.—Communications inside the defence.
4.—Improve rough cover for firing line and prepare second line very roughly.
5.—Improve obstacles and possibly provide cover trenches for second line.
6.—Improve second line and make keeps.

In a hastily fortified position 1, 2, 3, and 4 can usually be done.

VILLAGES AS DETACHED POSTS ON LINES OF COMMUNICATION.

Small towns and villages will often form posts on the lines of communication, and as they can be attacked from almost any direction, must be prepared for all round defence. The measures taken for defence will greatly depend on the probability of artillery being included in the attack. Very often a great deal of ground outside the village will have to be included in the area defended, being required for grazing for transport animals, etc. It may be necessary to occupy positions commanding

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the village to prevent them being seized by the enemy. In the event of artillery attack being probable, it may be necessary to push out the line of defence to a distance sufficient to bring effective infantry fire to bear on ground from which the enemy might effectively bombard the village. When from any of the above considerations the village itself will not form a satisfactory main line of defence it will generally be necessary to hold the increased perimeter entailed with small bodies of men at intervals, as the numbers of the garrison for a detached post would not usually allow of any other arrangement. These small bodies by day can, if artillery attack is anticipated, find cover in fire trenches or behind natural cover and support each other at fairly long intervals. At night, however, it is essential in posts that are likely to be surrounded for each man to fight where he is, and there can be no question of reinforcements. The posts for night for the advanced positions would therefore best be *closed works*, such as blockhouses or small redoubts, provided with a *good obstacle* close to them. The village itself should also be strongly prepared for defence, each unit being prepared to defend its own sleeping place. If the enemy penetrates the advanced line there will be no confusion, and he will probably be bumped from pillar to post throughout the night. Very often the only possible means of advance by night is along roads and tracks, and the advanced posts will usually be sited to command such means of approach. The telephone would be a most useful adjunct to the defence.

Generally in this class of defence there will be ample time at disposal to go in for much more elaborate works than in the case of positions. If a post has to be prepared for defence in a short time do not let the elaboration of cover prevent the formation of obstacles.

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DEFENCE OF HOUSES.

A house may be used:—

1.—As a tactical point on a battle-field.
2.—As a keep to a village, or locality.
3.—As an isolated post on a line of communications.

A house is of little use if exposed to artillery fire, though it may be used to give cover to troops in the back rooms or behind it. Houses not exposed to artillery fire or screened from the effects of artillery fire are of the greatest value for the defence.

The garrison should always be a tactical unit, and may be estimated at 1 to 2 men to each window, door, or loophole; with a reserve in addition of one-fourth.

To what extent a house may be fortified depends of course upon the time available for work. For a very hasty defence, time one to three hours, the following are the successive steps which should be taken:—

1.—Clear field of fire.
2.—Barricade entrances.
3.—Provide loopholes.

These measures are all equally important, and should be put in hand together.

For a deliberate defence, time 24 to 48 hours:—

1.—Make a rough survey of the house and grounds; mark out a defensible *enceinte*, and decide what out-buildings, etc., shall be pulled down or left standing.
2.—Clear a field of fire, and arrange obstacles; and remove all inflammable materials, etc.
3.—Prepare and strengthen the defensible *enceinte* decided on. Barricade doors and windows, make loopholes, and provide flank defence. Arrange for water, stores, ammunition, hospital, etc.
4.—If distant artillery fire is anticipated, prepare fire trenches for the garrison outside the house on the flanks.

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A large building may even be prepared for internal defence by loopholing the interior walls.

If there is no time to barricade windows they can be screened by blankets, etc. The ground floor windows and doors should be done before anything is attempted with the upper floors. In some cases the upper floors may command ground unseen from the lower, in which case they are equally important if time permits.

DETAILS OF DEFENCE.

Doors and windows may be barricaded in many ways, *e.g.*:—

1.—Boxes, chests, or cupboards, filled with earth or bricks, may be placed against them.

2.—A wall of bricks, etc., may be built up against the door inside, and supported by another door, taken from an inner room, strutted against it.

3.—Planks nailed on outside and inside of frames and filled with road metal, broken brick, coal, etc. (See Chap. VIII.)

4.—Sand-bags, coal sacks, pillow cases, etc., filled with earth, stones, etc., and made into rough walls.

Other methods will suggest themselves.

The door reserved for use should be one, if possible, which cannot be fired into from the outside. It will be hard to make it bullet-proof and able to open. A cupboard, etc., filled with earth and mounted on rollers, might be placed against it.

Loopholes in a house will ordinarily be about 4 ft. apart, but the minimum intervals will be regulated by the thickness and strength of the walls. They must always be 6 ft. clear of the ground on the outside, except those for flanking fire, which may with advantage be made close to the ground.

On the ground floor, loopholes should be horizontal, so as to allow of considerable lateral range, but on the

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upper floors they must be vertical, to admit of depression of fire. Their number and situation will depend upon the amount and direction of fire. More than can be used at one time may be provided, so that the fire can be increased if necessary in any given direction.

Obstacles should be freely used round a house prepared for defence, and are particularly valuable at night. A good obstacle is better than flank defence, but arrange for both if possible.

Flank defence may be provided by using projections such as porches, bay windows, etc., or balconies (which fire downwards) or by making machicoulis galleries or tambours. (See Chap. VIII.)

A Machicoulis gallery is a kind of improvised balcony, made by laying two strong beams on an upper floor, and pushing them out through holes knocked in the walls at the floor level (generally on either side of a window) till they project some 4 ft. or 5 ft. The inner ends are securely lashed to the floor joists, and on the projecting ends some planks are laid to make a platform, or a 4-legged table is placed upside down, and a parapet of sand-bags, etc., built up all round nearly breast high. This arrangement will enable a few men to fire down the side of a house, or on to a doorway, or entrance, requiring protection.

DEFENDING A HOUSE AGAINST ASSAULT.

1.—*Against Infantry by day.*—The garrison firing from their loopholes will inflict all the loss they can upon the advancing enemy, but if overpowered by a superior fire it is better to withdraw from the unequal contest, and await the final assault which the assailants will be encouraged to make when the fire of the defence slackens. At this time a rapid and concentrated fire poured in on them, particularly when they are checked by obstacles, ought to be very effective, and will not improbably beat them off.

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2.—*Against Infantry by night.*—Take every precaution against surprise, and by constant patrolling guard against the lodging of explosives. When the attack does take place, concentrate a heavy fire on the line of obstacles. It is sure to be effective, and is the best chance of beating off the assailants.

3.—*Against Artillery and Infantry combined.*—If the house is screened from *distant* artillery fire, always reserve some of your fire till the guns come within musketry range. Then concentrate it on the detachments and teams, and finally on the assaulting columns.

If the house *can* be shelled from a safe distance, it will generally be necessary to evacuate it, and occupy fire trenches outside. If it is set on fire by shells, endeavours should be made to put out the flames. When the cannonade ceases, and the infantry advance to the attack, the house, if still defensible, should be re-occupied.

ATTACKING A FORTIFIED HOUSE.

1.—*Infantry alone by daylight.*—A strong body of skirmishers will envelope the house, and try to keep down the fire from the loopholes. Under cover of their fire, a storming party with powder bags, gun-cotton, crow-bars, etc., will advance, and try to force an entrance. The advance will generally be directed on a salient, or wherever the defence seems weakest. A tambour sometimes affords a favourable point to attack. Having penetrated the line of obstacles, the assailants should spread along the walls, and grapple with, and bend the defenders' rifles, etc. Once inside the building, if resistance is protracted, the place should be set on fire. Two or more attacks should always be made on a house at the same time to divert attention.

2.—*Infantry by night.*—A previous reconnaissance is essential to avoid mistakes and confusion in the dark, and to learn what obstacles, etc., will have to be overcome. The troops for the attack should be assembled

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as secretly and silently as possible, as surprise is of the first importance. If explosives have to be used to remove obstacles, or effect an entrance, every effort should be made to lay the charges, and ignite the fuzes, unseen. The men should not stop to fire, but get to close quarters at once.

3.—*Infantry and Artillery together.*—The guns from a distance will concentrate their fire on the building, with the probable result that the defenders will be driven out, and the place set on fire. The infantry will then only have to deal with an outer line of defence, if one has been prepared. But should it happen that the house is still defensible, the guns must cease firing, when the attacking infantry get to close quarters, when, should they, after all, fail to force an entrance, some guns must be brought close up to try and breach the walls.

If the house is screened from distant artillery fire, the attack must commence in the same way as an ordinary infantry attack by day, but as soon as a decided impression has been made by them, some guns must be brought close up, to endeavour by their fire to smash down obstacles, breach the walls, etc., etc. The infantry will then deliver their assault.

DEFENCE OF WOODS.

The occupation of woods, as in the case of villages, is generally enforced by tactical reasons. Woods vary so much that no detailed rules can be laid down. Generally speaking, the defence of woods may be classed under three headings:—

(1) When the front of a wood is in the general run of the front line of a position.
(2) When the rear edge of a wood is in the line.
(3) When a large wood that projects for a considerable distance both to front and rear crosses the line of a position.

Taking case (1). The wood may be organised in sections on much the same lines as a village. Digging in

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woods is generally out of the question on account of the roots. The front edge of a wood is very often a *good mark for the enemy's artillery*. In this case a good position for the firing line may be found in *fire trenches in front of the wood*, and the wood used as cover for reserves.

Probably shell fire, if not materially destructive, would be very demoralising to troops inside a wood.

On the other hand, artillery would seldom shell a wood for any length of time, as they can seldom know what the effect of their fire is, and ammunition cannot be expended on the chance of its being effective.

Communications through the wood should be very carefully organised, and distinguished by finger posts, blazing trees, etc.

Generally, if the edge of a wood is occupied, the only practical protection you can obtain in a hastily fortified position is the concealment and obstacle obtained by entangling the edge of the wood and clearing a path all along the front to facilitate lateral communication, leaving a fringe of trees standing to screen it.

It might be possible to make rough cover, *e.g.*, log stockades, at the salients, and entangle the remainder, in addition to the path along the front edge. These salients would give some frontal fire and flank the entanglement.

In holding the front edge of a wood, the points to remember are:—

(1) *Fire trenches* in front of the wood will often be the best position for the firing line.

(2) If front edge must be held, make the most of the *concealment* afforded by the wood and improve the *communications* as much as possible. Digging is often almost out of the question. Rough log breastworks will give partial but not complete protection.

Guns are better outside a wood, on the flanks, than in it. If unavoidably inside, they should be on or near a road by which they can retire.

An inner line of defence should be arranged, if possible, any existing open space, stream, or road being utilised for

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the purpose. It should be strengthened by entanglements, abatis, etc., and as much clear space left in front of it as possible.

Taking case (2). The rear edge of a wood would seldom be held, and it would generally be possible to retire the line so as to command the *rear edge* of the wood. This rear edge should be entangled, and all paths leading out of the wood blocked. Very often, in a position like this, particularly if the wood is a large one, no artillery fire is to be feared, and there will be no chance for counter-attack.

Hence the defence may be a passive one, and the obstacle improved *ad libitum*, while blockhouses, small redoubts, etc., at intervals will greatly reduce the number of defenders required for this portion of the position.

In case (3), if the wood is too large to act either as in case (1) or case (2), a clearing may be made through the wood. The edges of this clearing can be entangled, and the clearing flanked by the fire of the defence. If too large to flank the whole clearing conveniently, portions may be flanked and other portions in the interior of the clearing widened and defended by frontal fire.

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CHAPTER XI.

REDOUBTS AND POSTS.

Redoubts are works entirely enclosed by defensible parapets.

Their great value lies in their resistance to *infantry* attack at close quarters.

Field howitzers could render a redoubt untenable if they could mark its position and observe their fire.

REDOUBTS IN POSITIONS.

Generally speaking redoubts would rarely be used *in the front line of a position* unless they were intended to be used on much the same lines as *detached forts* in the permanent defence of a fortress, viz.: as pivots, or artificial flanks to the various sections of the front line.

Such redoubts would have to be concealed very carefully and the command would have to be kept as low as possible, as *invisibility* is essential.

When, owing to the enemy's artillery fire, the defenders of the fire trenches in the intervals might have to be withdrawn, by arranging such redoubts to give strong flanking fire, and providing good splinter-proofs, they might serve to keep the intervals intact till the trenches in them could be re-occupied. Redoubts for this purpose might be content with a frontal field of fire, only sufficient to stop a rush (say about 400 yards), provided the intervals could be swept by the flanks and that such a site would give invisibility.

Permanent fortification provides such redoubts with *bomb proofs;* but their use with only splinter-proof cover, which is all field fortification can attempt, would be somewhat doubtful.

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The section and profile of redoubts vary according to the command required and time available for construction.

As howitzer fire is to be avoided, the low command redoubt has great advantages in concealment, and the ordinary fire trench sections may be adopted (see Fig. 4, Plate III., and Fig. 2, Plate IV.) in the first instance and improved afterwards. The Manual of Military Engineering shows a type of low command redoubt, the parapets of which are merely deepened, and widened fire trenches. The flanks will have to be well traversed and often recessed.

Short lengths of overhead cover for about 10 men each, allowing 2 ft. per man in one row, and 1 ft. per man in two rows, are provided in the interior of the work. Access to the parapet and to each other is arranged by joining up the lengths of the overhead cover with deep communication trenches (see Pl. VI., Figs. 3 and 4; Pl. VII., Fig. 4). The splinter-proof cover is best arranged parallel to the front.

Redoubts as rallying points, behind the front line of the position, can generally be withdrawn from view of the enemy, and *invisibility* will be more easily secured.

REDOUBTS IN ISOLATED POSTS.

In isolated posts, artillery attack on a large scale is not usually to be feared, hence invisibility has not the same importance as in the case of redoubts in a position. Generally the redoubt will be on high ground to avoid being commanded, and a high parapet is generally required to conceal the defenders from view. The high parapet also helps to improve the moral of the defenders, and the field of fire. Any small body of men liable to be surrounded must have an all-round defence, and a good obstacle for night work.

Splinter-proof cover should be freely provided, if artillery attack is possible, and there will usually be ample

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time to elaborate defences in small posts of this class. If artillery fire can come from several directions, the splinter-proofs must face various ways, and parados will be very useful.

Water supply may give a lot of trouble, as the only water supply available may be on low commanded ground. The difficulty may be met:—

(i.) *By storing water.*—A very doubtful expedient as storage will need replenishing, and is liable to accident. Some more certain supply is advisable.

(ii.) By making *a post* at the water supply; putting the redoubt on nearest commanding ground and arranging for communication.

(iii.) By making the redoubt at the water supply in which case extra high parapets, deep trenches, traverses, parados, etc., will be necessary, and placing a post on the ground commanding the redoubt.

Most careful arrangements will have to be made for cooking, sanitation, storage of food, ammunition, etc., and very often cover for animals. If, however, the redoubt is not on the lines of communication, but merely an advanced post, supporting the cavalry screen in front of an army, it could be quickly supported, and the question of water supply, etc., would be easily solved; nor need the cover provided be of such an elaborate nature.

Although isolated posts can generally be improved subsequently *ad libitum*, nevertheless they will often have to be started when the enemy may quickly attack. In this case there may not be time to make a parapet high enough to cover the interior from view before night. The obstacle should in no case be sacrificed to elaboration of cover, and it will be best to begin with a low parapet, giving fair cover, and a rough obstacle, rather than a good parapet, and no obstacle.

The raising of parapets, provision of splinter-proofs, etc., will of course follow, as time allows.

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ISOLATED POSTS.

The principles of a large isolated post will be exactly the same as already referred to on page 143 in the case of a village.

Smaller posts may often form a large redoubt composed of two or smaller redoubts, connected by obstacles, and such screen parapets, trenches, etc., as ground requires and resources of the defence will allow. The animals may often find good natural cover.

TRACE OF REDOUBTS.

Practically a redoubt may be any shape that will avoid dead angles and give a field of fire in the required directions. A man cannot comfortably fire much more than 15° away from the perpendicular to the line of the parapet, so angles sharper than 150° should, if possible, be avoided.

The circular shape does this, but, except for very small redoubts, gives no particularly strong fire in any one direction.

Avoid small faces, as it is not safe to pin the safety of a large redoubt on two or three men. For a large redoubt about 10 men is the least that should be put on any one face.

Generally speaking, in redoubts about one to two men per pace of parapet will form a good basis for calculation. This would, of course, not generally be found possible to apply to the case of a post, where a large area had to be enclosed, and proportion of men to parapet might be very much smaller.

It will be found advisable, whenever practicable, to adopt a plain rectangular or square trace where simplicity is desirable.

The trace of a work will depend on the proposed garrison, and this should always consist of one or more tactical units.

The proportion of garrison to size of work should be from 1 to 1½ men per yard.

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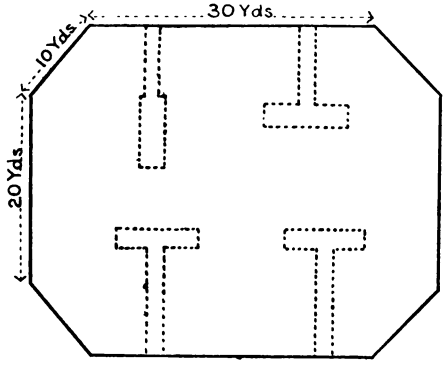
The longest face should be arranged to fire on the enemy's best line of advance.

The following shows the trace of a redoubt for 150 or 200 men.



This has been arranged as follows:—

Two faces, 30 yards each	=	60 yards.
Two faces, 20 yards each	=	40 yards.
Four flanks, 10 yards each	=	40 yards.
Total	=	140 yards.

Shelters are made with communication trenches inside the work.

It is very hard to get an ideal trace, and generally the gorge will have to be much longer than its relative importance requires, and to avoid excessive depth in the redoubt the flanks will often work in to the gorge at an angle of 90° or less. Much can be done by blunting angles with short faces, or using rounded angles.

The ground also has to be considered. Sometimes a great saving of labour can be gained by slightly modifying the trace, so as to fit in with the contours of the ground. Sometimes when redoubts are forming a post, it will be necessary on very steep ground to cover ground in front of one redoubt by flanking fire from its neighbour.

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To avoid the conspicuous angle at the ends of the front face, it may be necessary in the case of a redoubt where concealment is essential to prolong the front face outwards beyond the flanks, thus making the redoubt look like a fire trench when viewed from the front.

GUNS IN REDOUBTS.

Guns in a position would never be placed in redoubts, as their mobility would be lost. Even in permanent fortifications guns are only placed in forts owing to the necessity of having an armament ready mounted for the outbreak of war. Such guns are protected by masses of armour, and are worked by complicated mechanism.

In isolated posts guns are better mobile, but sometimes emplacements will have to be made for them inside the post. A field gun requires about 10 ft. by 6 ft. in plan.

ENTRANCES, ETC.

Entrances would usually be simple cuts in the gorge parapet in redoubts in a position. In isolated posts arrangements would have to be made for closing the entrance at night and the gap in the obstacle opposite it. Against a savage foe care would have to be taken to prevent the entrance forming a weak spot in the defence.

The garrison of a redoubt, especially if confined for long in splinter proofs underground, would be damaged both in health and in moral, unless the redoubt was as well drained as possible. Soak pits will rarely meet the needs of the situation, and drainage should be begun from the first, or at any rate as soon as improvements in essential cover are started.

Manual of Military Engineering shows a type of high command redoubt, and various ways of fitting in splinter-proof cover inside it. See also Pl. XIII.

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EXECUTION OF REDOUBTS.

Having settled on the trace and command necessary, *spitlock* the trace of the *crest* line out on the ground, and put down tracing tapes to mark the cutting line of tasks for 1st Relief. The position of these tapes is easily measured off a rough hand sketch section, *e.g.*, in Pl. XIII. and Ex. 9, Chap. V.

Profiling will only be required for redoubts of high command. When your profiles are up see if any modifications are required by actual experiment, as it may be your calculations are a shade out.

The next thing is to make the men up into gangs, each gang under a superintendent, and get them extended on their various jobs ready to begin work. For method of extension on tapes see Infantry Training. When all are ready commence work.

The superintendents being relieved at alternate hours to working parties enables the work to carry on automatically. If the working parties are natives, it will be best to let them work their own way, under their own headmen, provided the general system of work is well superintended.

COMMAND OF PARAPETS TO GIVE COVER FROM VIEW TO INTERIOR OF WORK.

Cover from the *searching effect* of artillery projectiles has already been fully discussed. The *command* necessary to give a field of fire has been also dealt with. Against works exposed to modern artillery, cover from view need not be considered, as cover from fire entails much greater protection. In isolated posts, however, as already explained, it is often necessary to screen the interior of the work from view. This will in many cases provide also very fair cover from rifle fire when the protection is bullet-proof, unless the range is long and the angle of descent of a rifle bullet adds appreciably to the angles of view from high ground in the neighbourhood of the work.

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The interior of a work may be sheltered from view in three ways (putting casemates, etc., out of the question).

1.—By the command of the parapets.
2.—By throwing up traverses and parados.
3.—By digging trenches.

The following examples illustrate the manner of obtaining cover from view by the above means. To be strictly accurate, the height of a man might be added to the high ground, but such detail is hardly necessary:—

1.—Eight feet of cover is required 40 yards in rear of a parapet, in front of which, at a distance of 2,000 yards, is commanding ground 110 feet high. What must the height of the parapet be?

Fig. 1, Pl. XXIII., explains itself, P being the position of the parapet. Here we have two similar triangles, of which the bases are respectively 2,040 yards and 40 yards, and the perpendicular 102 feet and x feet. Consequently a simple proportion will give us x:—

$$2{,}040 : 40 :: 102 : x \text{ feet.}$$

From which $x = 2$ feet, and, therefore, the parapet must be 10 feet high.

2.—A and B are two opposite parapets of a square redoubt, 30 yards side, command, A, 8 feet; B, 6 feet.

D is a hill 98 feet above the plane of site of A B, and 600 yards in front of A. It is determined to make a parados 10 feet high to protect the defenders of B parapet from reverse fire from D. Find how many yards from B the centre of the parados should be placed to allow the fire from D to pass 2 feet above the crest of B.

Here from the figure (Fig. 2, Pl. XXIII.) we have the two perpendiculars, 90 feet and 2 feet respectively; and one base, 630 yards. From these data, the other base, x can be found at once, thus:—

$$90 : 2 :: 630 \text{ yards} : x \text{ yards.}$$

From which $x = 14$ yards.

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3.—A hill 110 feet high is 1,025 yards in front of a parapet 7½ feet high. Find the depth of a trench 30 yards behind the crest which will afford 7 feet of cover.

In this case we see from the hand-sketch (Fig. 3, Pl. XXIII.) that two bases are known, *viz.*, 1,025 yards and 30 yards, and one perpendicular 102½ feet, the other perpendicular is therefore 3 feet for—

$$1{,}025 : 30 : 102\tfrac{1}{2} : 3$$

The trench therefore must, evidently, be 2½ feet deep to give cover required, *viz.*, 7 feet.

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CHAPTER XII.

APPLICATION OF FIELD FORTIFICATION TO TACTICAL SCHEMES.

Most of the examples already given in this book to illustrate the calculations necessary in estimating men, time and tools necessary for various kinds of work, have merely shown the one particular work by itself. In most tactical schemes, however, the question is made much more complicated.

(i) Because the time is limited.
(ii) The tools are limited.
(iii) The working party available may be very small.

It is not proposed to treat of deliberate schemes of defence thought out long beforehand, and for which ample provision in the way of working parties and tools necessary has been made. In such schemes it is generally only a question of spreading the work over a number of reliefs in such a manner that the working party for any one relief is not inconveniently big when compared with the other reliefs, and also that the tools required are used to the best advantage. Very often some days are available for the execution of the necessary works, and there is no need to leave anything advisable undone. Nor need the work be executed in order of importance, as would be the case in hasty defence, but in the most convenient order. In most hasty schemes of defence *time* is limited. Owing to the probability of almost immediate attack, *tools* will generally be limited to those carried by the troops, and possibly a few tools found on the spot, and the *working party* available will only be the troops who are going to fight. Works are of secondary importance to men, and however good the works were, they would serve no effective purpose if they were defended by a jaded garrison. Consequently only

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a proportion of the troops may be available for work, the remainder being carefully nursed for the fighting.

In considering any tactical scheme, therefore, it is essential to know exactly how you stand with regard to time, men and tools. Occasionally the needs of a particular position may be known beforehand, and special tools carried to be available for its defence.

Limited by the above-mentioned three restrictions, the ideal in most cases cannot be reached, and the question is greatly one of give and take. The great point is not to strive too much for the *absolute best*, but reason the problem out according to the time and means available, and make a decision as to what should be done and stick to it. There may be many other ways of organising the defence, some of which are better, but if you have settled on measures of defence that can be done in the time available, and which are based on sound fundamental principles—such measures will, in ninety-nine cases out of a hundred, be good enough for the purpose intended. War does not usually allow time to thresh out the finer points of theory, and the main thing is to get something done.

An example of a small tactical scheme will best explain the points that are intended to be brought forward for the student's consideration. If he will remember that the example only applies to the particular conditions stated, there should be no difficulty in dealing with most of the problems of a similar nature that arise in the field. If a hasty problem can be well worked out, a more deliberate one should not present anything like the same difficulty. In large schemes the work should be divided into sections, marked by well defined natural boundaries and occupied by tactical units. Any section larger than the example given as a type might well be subdivided. The example given is not only intended for examination purposes, but is a very useful guide to a sound method of detailing parties for such a piece of work. There would generally be time for the officer organising the work to go round the section, make a rough sketch or verify any map supplied to him, note

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the position of the firing line, growths to be cleared, etc., etc., and jot down in a tabular form the tools and men for the various items to be done. Orders can be issued based on this table, and tools laid out ready for the different parties. Soundly estimated for on broad lines, such a scheme has far more chances of being properly executed than if left to chance. A few of the main points to be borne in mind are here enumerated.

(i) *Get the work done.* Use the rules in books and common sense as a rough calculation, and take care to have plenty up your sleeve by having a good safe margin.

(ii) *Keep to units.* Never mind even if the party seems a little too large. The difficulty can often be met by grouping various small items together whose position allows them to be superintended by one officer. There is nothing more unpractical than entering too minutely into detail. It confuses the general scheme, and something must be left to the common sense of the superintending officers. In a battalion scheme half a company is about the smallest body of men there is any need to detail. Nevertheless, in thinking out the scheme for yourself you will often have to be very careful in thinking out how much a few men can do, if you combine several small parties to do many such jobs. A small error multiplied by a big factor may become a large error.

(iii) If getting the work done in two reliefs take care that the same party do not *dig* both reliefs. Length of reliefs depends entirely on circumstances, climate, etc.

(iv) If likely to be attacked, get fair cover and your immediate front cleared straight away. Improvements to field of fire and cover, and provision of obstacles may follow. For night work in isolated posts obstacles should come before improvements to field of fire and cover, especially against savages.

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(v) The best way to arrive at a decision of what can be done is to make out a tabular form. Write down the men and tools at your disposal at the head. Then see what are left after the essential things have been done, and consider how to use these for improvements. By adjustment of the various items a very fair scheme may be got out.

Make the tables as clear as possible, and it is better not to identify places by letter A, B, C, etc., but describe them so that the table alone could be acted upon, *e.g.*, Hedge A B would convey no information to anyone unprovided with the map on which the letters A B had been marked.

State tasks for digging, and give all information you can that you think will be wanted by anyone actually executing the various jobs. Sketches in the remarks column are very useful to make clear points that are hard to explain.

Plate XXIV. and the table on pages 170, 171, give an example of a section of a position to be prepared for defence. The enemy is advancing from the direction of Essing. The boundaries of the section are the London-Essing Road and Meeston Lane, the general run of the section being along the Heng Road. The section has similar sections on either side, and is about the centre of the position. Neither of the roads forming the boundaries are to be included by this section in its defensive arrangements. Four hours' work may be expected from the whole force, but only half the force may work another four hours, as the position is to be ready for defence in eight hours, and some of the troops must have a rest.

The garrison of the section is—

One battalion of eight companies infantry (each 100 strong).

One battery field artillery.

One section field company Royal Engineers (about 30 available for work).

The tools assumed to be carried by the troops may be seen in the table on pages 170 and 171. They are taken

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from the Field Service Pocket Book, and a few additional tools are assumed to have been foreseen and carried by the Royal Engineers. In calculating tools found on site only estimate for those you actually find.

The artillery and their tools have been left alone, it being assumed that they will act independently and do their own work. If required they can provide their own cover, range marks, communications, etc. The Royal Engineers have been used for superintendence and any work skilled labour is likely to be useful on, explosives, etc.

It will be seen from Plate XXIV. that the section has extremely close country on the right, and very open country on the left. Trenches 2, 3, 4, are down among the tree trunks of the orchards, and can see for about 100 yards without any clearing. After this point extensive clearing is necessary. About 400 yards field of fire has been obtained, and a very strong obstacle made of the cleared stuff. The orchards left standing help to screen the trenches behind them.

The artillery position has a good view, and the guns have excellent communications, as all the roads are good. The hop field in front partly screens the guns, and is left standing. Trenches 5 and 8 are just inside the edge of the hops, which form a screen. It will be noticed that all the trenches are sited so that communications to them through orchards, hops, etc., are fairly well screened from view. Supports and local reserves can find cover in the orchards on the reverse slope.

The left portion of the section is left free from obstacles, as it is considered suitable for counter-attack, being open and abreast of the London Road. The right portion, owing to its limited field of fire, wants an obstacle.

The enemy have two very strong artillery positions, 3,500—4,000 yards away, bringing an oblique fire to bear, hence it is desirable to make recessed trenches if time permits.

Most of the fences in the orchards are wire, but the hedges along the roads are fairly thick, and Black Lane must be cleared both sides. The hedge is on a small

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bank, so that the road may well be filled with the debris.

Grange Farm has been demolished. A good deal of it is wood, and will burn. Pendip Farm is too far out to tackle. It is right under the fire of the battery.

Green Farm and houses north of the Heng Road are too visible to the enemy's artillery to be worth doing anything to. A great many of the outbuildings are wood. Thorndale House, The Vicarage and School are strong, substantial brick buildings, and are fairly sheltered from the view of the enemy. Thorndale House might be very useful against a turning movement.

Wells in the farms and houses can provide a good water supply, the section being on the flank of a large village.

The ground is fairly easy, and concealment can be easily obtained by small branches and sods.

No map or report can bring all the natural features of a piece of country before the student's eye, and this scheme is only intended to bring out a few general principles.

Referring to the table, it will be seen that the main problem is to get all the work out of the cutting tools, the field of fire on the right being the first consideration. The tools are few in number for the work, so clearing must be *judiciously* done, and a party has been left in the second relief to give the finishing touches. The cleared stuff is all used to fill up the hollows or to make abatis. The calculations have been made as in the examples shown in Chapters VI. and IX., except that the tools in this case have to fit in with other work.

Having used up all the cutting tools in the first relief, the digging tools can next be considered. It is desirable to make trenches for half the force, leaving the other half in local reserve. Trenches should also, if possible, be recessed, so more length of trench is wanted than if plain trenches were made. The examples on Chapter V. have shown many of the usual cases. The tools in this case are made to suit by digging seven half-company trenches, and recessing them in the first relief. Another recessed trench is begun and completed in the second relief. Two companies still remain for work after

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digging and cutting tools have been usefully employed in the first relief, and advantage is taken to improve the field of fire by trying to properly demolish Grange Farm, which obscures a lot of ground behind it, and allotting one company to this job. The remaining company improves Thorndale House, the School and Vicarage as a second line of defence.

The abatis had to be made in the second relief to allow the cutting tools to go round. A great many odd jobs in connection with the field of fire would be better met by allotting one company to this work, than trying to do a little more clearing to the north. If the first relief left little to be done in the cleared area clearing northwards would be understood as improving the field of fire.

It is hoped with the aid of the above brief extra description the table on pages 170 and 171 and Plate XXIV. will usefully repay a certain amount of study.

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Infantry.	R.E.	Description of Work.	Picks.	Shovels.	Axes. Felling.	Axes. Hand.	Saws. X cut.	Saws. Hand.	Billhooks.	Spades.	Crowbars.
8 Cos.		Tools carried	148	222	16	8	1	1	46	—	8
——	¼ Fd. Co	Do.	27	28	10	6	1	4	12	3	2
——		Found in Farms, etc.	2	2	—	—	—	—	8	7	—
8 Cos.	¼ Fd. Co.	TOTAL TOOLS AVAILABLE	177	242	26	14	2	5	60	10	10
1ST	RELIEF—4	HOURS.									
1 Co.	1	Clearing Cherry Orchard, S. of GRANGE FARM and hedges both sides BLACK LANE from LONDON ROAD to MEESTON LANE.	—	—	13	6	1	1	50	—	—
1 Co.	1	Dragging cleared stuff to hollow in N.W. corner of orchard and to site of abatis S. of GRANGE FARM.	—	—	—	—	—	—	—	—	—
1 Co.	1	Thinning orchards around GRANGE FARM on N. side of BLACK LANE and dragging cleared stuff to site of abatis in BLACK LANE and to hollows in S. edge of orchards.	—	—	12	6	1	1	9	—	—
1 Co.	10	Demolishing and levelling GRANGE FARM. Burning all wooden buildings.	23	9	—	—	—	—	—	—	7
3 Cos.	7	Excavating, recessing, and concealing 7 trenches, each trench to consist of 8 30 ft. sections of 3 ft. × 3 ft. trench with a parapet 1 ft. 6 ins. high. Traverses 5 ft. wide at base to be left between the sections.	147	147	—	—	—	—	—	10	—
1 Co.	3	Burning wooden houses and outbuildings, and preparing THORNDALE HOUSE, the VICARAGE and SCHOOL, for defence.	6	30	—	2	—	2	—	—	2
——	7 or remainder available.	Communications along the section.	1	1	1	—	—	1	1	—	1
8 Cos.	¼ Fd. Co.	TOTAL 1ST RELIEF	177	187	26	14	2	5	60	10	10
2ND	RELIEF—4	HOURS.									
1 Co.	1	Improving the field of fire generally and making range marks.	—	—	18	4	2	2	8	—	—
1¾ Cos.	1	Making abatis along BLACK LANE.	—	—	8	10	—	3	52	—	—
1 Sec. (not part of the 3 Cos. on Trench-work 1st Relief).		Excavating and recessing Trench 8. 8 30 ft. sections similar to trenches 1 to 7.	21	21	—	—	—	—	—	—	—
3 Cos.	¼ Fd. Co.	TOTAL 2ND RELIEF..	21	21	26	14	2	5	60	—	—

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Gun-cotton, lbs.	Hammers.	Mauls.	Pliers.	Grindstones.	Sandbags.	Rope, fathoms.	Wire, miles.	Nails, lbs.	Remarks.
—	—	—	—	—	—	—	—	—	Taken from Field Service Pocket Book.
105	*8	*2	*4	*1	*250	*50	*2	*50	Do. *are assumed to be available.
—	—	—	—	2	—	—	—	—	10 carts and horses.
105	8	2	4	3	250	50	2	50	
—	—	—	—	2	—	—	—	—	Area to be cleared about 300 yds. along BLACK LANE and 100 yds. deep – 6 in. cherry trees 5× apart. About every third tree requires clearing.
—	—	—	—	—	—	25	—	—	5 carts and horses. Most of the hedge between GRANGE LANE and MEESTON LANE can be left in the road which is slightly sunk.
—	—	—	—	1	—	25	—	—	5 carts and horses. Area to be cleared about 400 yds. along BLACK LANE and 150 yds. deep—6 in. and 7 in. cherry trees 6× apart. About every third tree requires clearing.
100	—	—	—	—	—	—	—	—	Easy soil. Two men told off to each task. Tasks for trenchwork 10 ft. along line = (90) ,, ,, recessing (30) Two recesses one man. Passage round traverse (72) See Ex. 3, Ch. V.
—	—	—	—	—	—	—	—	—	No. 1 Trench, right flank MEESTON LANE, 80× N. of HENG ROAD.
									No. 2 Trench, close to and in same line with 1 along fence.
									Nos. 3 and 4 Trenches, left flank on GRANGE LANE, 100× N. of HENG ROAD.
5	7	2	4	—	250	-	¼	40	No. 5 Trench, 5× inside front of hops, right flank on GRANGE LANE, follows line of the bank.
									No. 6 Trench, 140× N. of GILES COTTAGE.
—	1	—	—	—	—	—	—	5	No. 7 Trench, left flank on LONDON ROAD, 120× N. of HENG ROAD.
105	8	2	4	3	250	50	¼	45	
—	8	—	—	2	—	25	—	5	5 carts and horses. Orchard in front of GILES COTTAGE to be thinned where interfering with fire of Trenches 6 and 7. Also portions of hedges in GRANGE & MEESTON LANES interfering with Trenches 1, 4, and 5.
—	—	2	4	1	—	25	1¾	—	5 carts and horses. As continuous a belt of abatis as possible to be made along edges of cleared orchards on both sides of BLACK LANE. About 300× on N. side and 150× on the S. in 1 Row.
—	—	—	—	—	—	—	—	—	6 recesses to be made in every 30 ft. section. Task 2 recesses or 30 cub. ft. per man. Trench 8 in continuation of Trench 5 along Bank of Hopfield. Task 10 ft. along line = (90) Task round traverses (72)
—	8	2	4	3	—	50	1¾	5	

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CHAPTER XIII.

MILITARY BRIDGING.

Knots and lashings.—The various knots and lashings most generally found useful in the field are all shown in Plates XXV. and XXVI. They can only be learnt properly by practice, not from description of them, but the particular uses to which each is appropriate must be noted.

A thumb knot is used for preventing the end of a rope from slipping through a block.

A reef knot is a good knot for joining two ropes of the same size.

A granny, and a *thief knot*, are *unsafe* knots, which are commonly mistaken for a reef knot, as they are all three very like each other.

A draw knot is like a reef knot, but can be cast off from a distance by pulling at one end of it.

Sheet bends, single and double, are used for joining two ropes together, and are better than a reef for this purpose, especially if the ropes are of unequal sizes.

A round turn and two half hitches is used for securing the end of a rope to a picket. In securing a guy, keep the turn *above* the standing part, so that there is no chance of it jamming.

A sheepshank shortens a rope fastened at both ends without cutting it.

A clove hitch is used for fastening a rope to a spar; it is the commencement of most lashings.

A timber hitch jambs when a strain is taken on it, so it is used for hauling spars, for foot ropes, etc.

A lever or man's harness hitch (Plate XXVII.) is used to form a loop on a drag-rope.

A bowline on a bight (Plate XXVII.) is a way of making a loop that will not slip in the middle of a rope.

A rolling bend, or hawser bend, is used for joining heavy cables.

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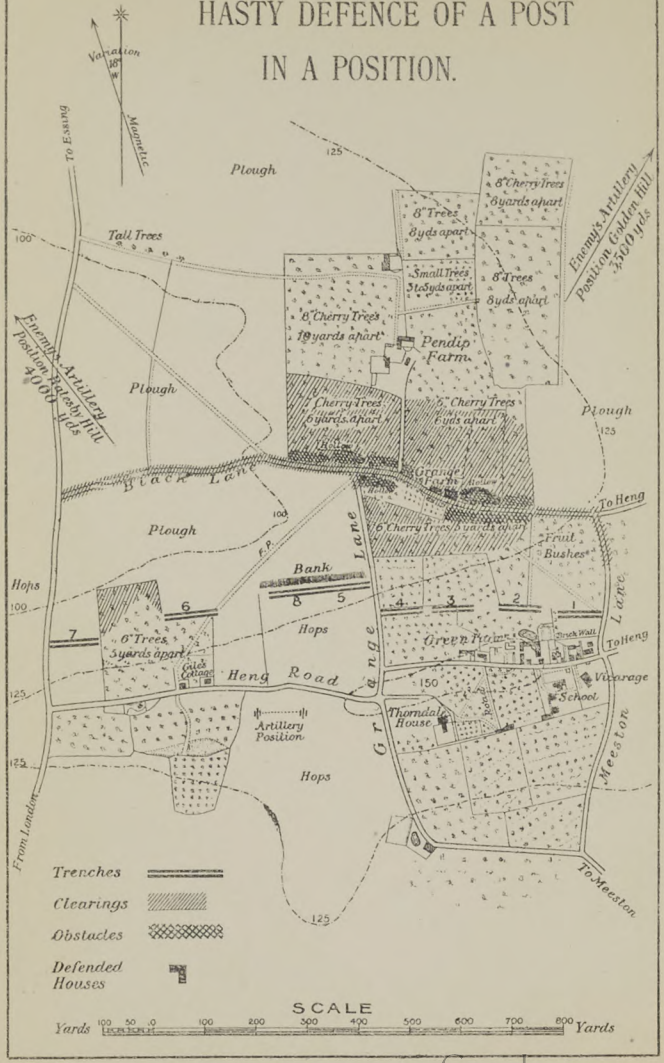
HASTY DEFENCE OF A POST IN A POSITION.



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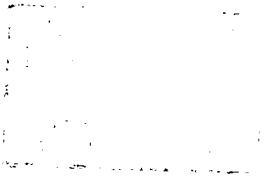

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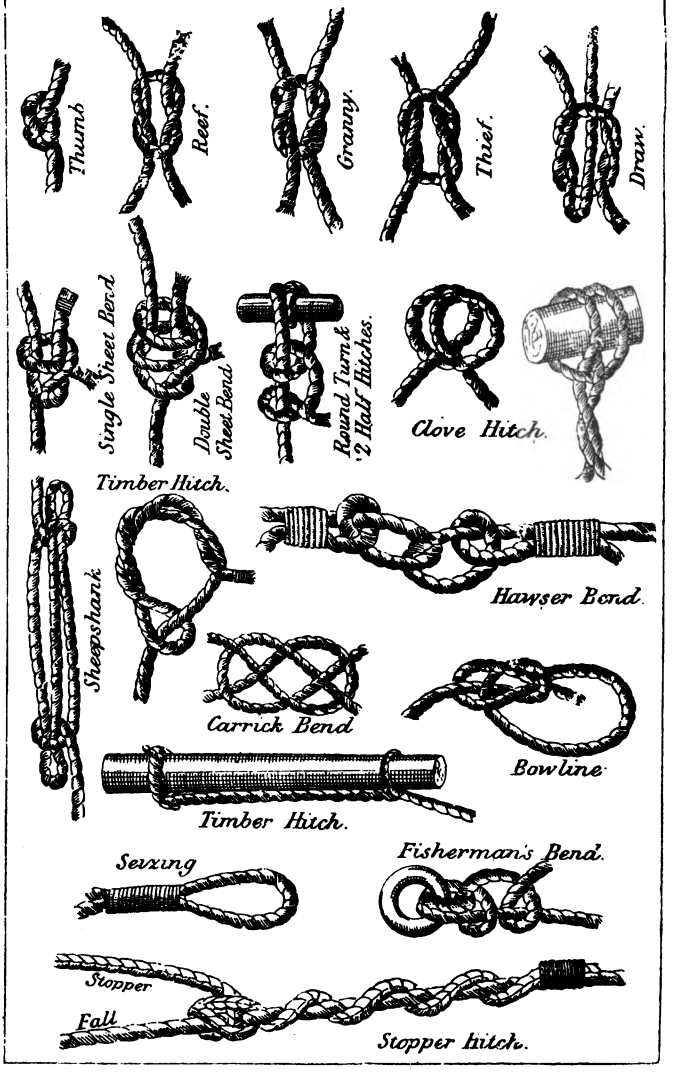
KNOTS.



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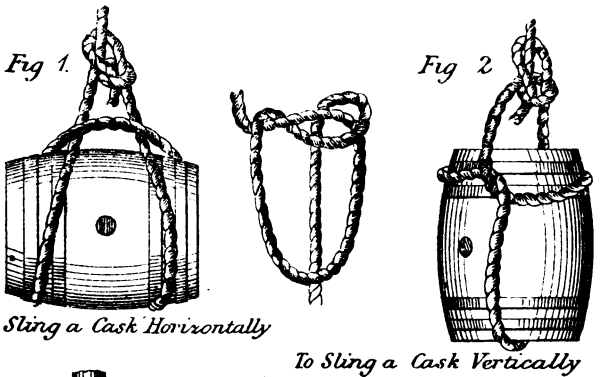
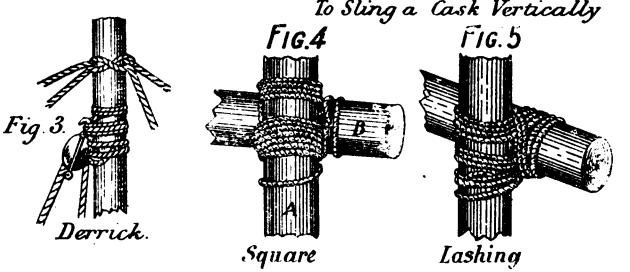
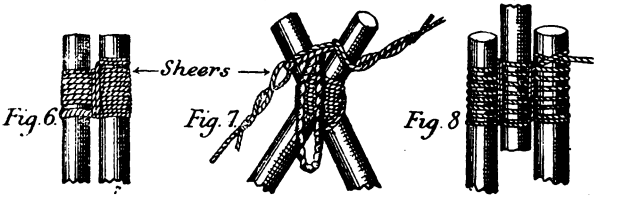
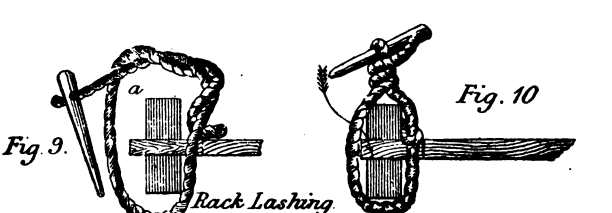
KNOTS AND FASTENINGS.









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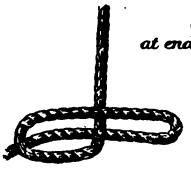

Fig 1

Fig. 2

Fig. 3.

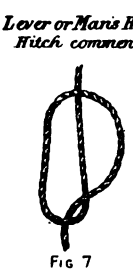

Fig 7

Fig.8

Fig. 9.

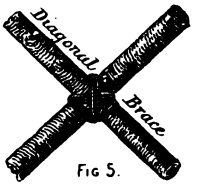

Fig 5.

Fig.5.

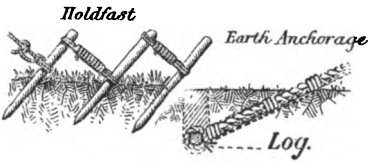

Fig 7 Fig 8.

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A fisherman's bend, for fastening a cable to an anchor, or a rope to a ring.

A bowline, for making a loop that will not slip.

A stopper hitch is used for taking the strain on the fall of a tackle, while it is being shifted on to a capstan, etc.

A carrick bend is used for fastening the four guy-ropes to a derrick. It is not much used.

Seizing a rope means securing the loose end of a lashing to the standing part of a rope, with yarn or twine.

To sling a cask horizontally.—Make a long bight with a bowline, and apply as shown in Fig. 1, Plate XXVI.

To sling a cask vertically.—Place the rope round the cask, make a thumb knot on the top, open it out, and slip each half down the sides of the cask. Then secure the standing part by a bowline. (Fig. 2, Plate XXVI.)

To lash a block to a spar.—Lay the back of the hook against the spar; take a clove hitch round the spar *above* the hook, then several turns round the hook and spar together, then some more turns round the spar *below* the hook, and finish off with two half hitches. (Fig. 3, Plate XXVI.) The hook of a block is *moused* by taking some turns round it with spun yarn, or twine.

To fix a rope quickly to a block, with a weight on it, a *catspaw* is made, either at the end, or in the middle of a rope (Plate XXVII.), or where the rope is pliant, and the weight is constant, a *blackwall hitch* may be used. (Plate XXVII.)

A square or transom lashing is used to lash one spar across another. (Figs. 4 and 5, Plate XXVI.) In a trestle start with a clove hitch on leg *below* transom—keep the turns on leg *inside* and on transom *outside* previous turns. Finish off on transom outside the bridge. In Fig. 4 A is the leg and B the transom.

A diagonal lashing (Plate XXVII.) is used to lash two spars together that tend to spring apart. Begin with a timber hitch, or running bowline round *both* spars, and draw them together, then take three or four turns across each fork, and finish with frapping turns.

A sheer lashing is used for lashing the tips of two spars together when they are lying alongside of each other. (Figs. 6 and 7, Plate XXVI.) A loose sheer

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lashing with good frapping turns is very useful for lashing temporarily the hand rails to a trestle launched on ways from the head of a bridge.

A gyn lashing is used for lashing three spars together to form a gyn. (Fig. 8, Plate XXVI.)

A rack lashing is an article of store. It consists of a sharp-pointed picket, with about eight feet of rope attached to its head, and is used for fastening down the ribands at the edge of the roadway of a military bridge. (Figs. 9 and 10, Plate XXVI.)

A derrick is a single spar kept in an upright position by four guy ropes. It is used for raising and swinging a weight into any position within its reach. (Fig. 3, Plate XXVI.) It can reach to a distance from the foot equal to one-fifth the height of the derrick. The guys must be at least twice as long as the derrick itself.

Sheers are formed by two spars lashed together with a sheer lashing, and held in position by two guy ropes, fastened to the tips of spars above the crutch, and arranged so that their action may tend to draw the spars closer together, not to strain the lashing. Sheers can generally be used for heavier weights than derricks, but can only move them in a vertical plane passing between their legs. (Fig. 7, Plate XXVI.)

A gyn has three legs, and consequently requires no guy ropes. It is good for stationary lifts, such as dismounting guns.

STRENGTH OF ROPES.

Anyone bridging must have some knowledge of approximately the safe working strains on ropes. The rules of thumb are very simple and easy to apply. A rope is measured by its *circumference* (c).

Hemp ropes or cordage may be *safely* worked up to c^2 *cwts.*, *i.e.*, a 3 in. rope may have 9 cwts. put on it. If bran new, as much as 18 cwts. or 2 c^2 might be put on, but no risks with hemp ropes should be taken.

Steel wire ropes may be safely worked with $9c^2$ cwt., and a 3 in. steel wire rope may have 4 tons put upon it.

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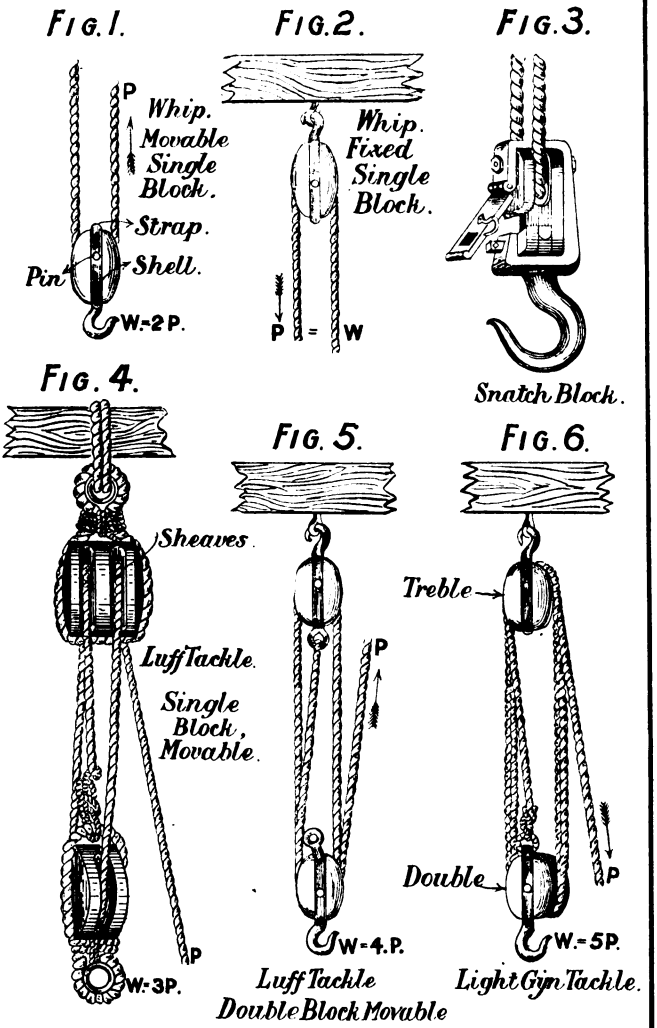
TACKLES.



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TACKLES.

A knowledge of tackles often saves a great deal of manual labour, and often enables a small party to do a fairly heavy piece of work.

The practical point to remember is that to use a tackle economically great pains must be taken to get as much gain out of the tackle as possible. Take care the sheaves are oiled. Take precautions to keep the tackle from twisting; a handspike or block of wood inside the returns will generally effect this. Use a soft rope for a *fall*.

Blocks are known by the length of the *shell*. (See Fig. 1, Plate XXVIII.) With wooden blocks the shell is three times as long as the biggest rope a block will take, *e.g.*, a 9 in. block takes a 3 in. rope.

The fall is generally led through a *snatchblock* (see Fig. 3, Plate XXVIII.) fastened to the foot of derricks, etc., at a convenient height from the ground for the party to get a straight pull. Parties of about 15 men can pull about 80 pounds per man. The fall may be led to a winch, capstan, etc., if available.

Tackles are exceedingly simple to calculate. The power required is the weight divided by the number of returns at the *movable* block, plus 10 per cent. for each sheaf for friction.

Example.—Using tackle in Fig. 4, Plate XXVIII., how many men would be wanted to lift 1 ton, and what size should the fall and blocks be?

Power required $= \frac{2240}{3}(1 + \frac{4}{10})$ lbs. 3 sheaves in tackle and 1 in snatchblock

$= 1{,}050$ lbs. or 9 cwt. approximately.

Men required $= \frac{1050}{80} = 14$.

A 3 in. rope will stand 9 cwt., so a 3 in. fall and 9 in. blocks are what is required.

Example.—What weight could be safely lifted with a 3 in. fall and the tackle in Fig. 6, Plate XXVIII.?

Power = safe strain on a 3 in. fall = 9 cwt.

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There are six sheaves, five in the tackle, and one in the snatchblock.

$$9 \text{ cwt.} = \frac{\text{weight}}{5} \times (1 + \tfrac{6}{16}).$$

$$\text{Weight} = \tfrac{45}{16}^{0} \text{ cwt.} = 28 \text{ cwt.}$$

In all cases when weights are lifted by blocks and tackles the top block must be secured to the derrick, etc., by enough turns of rope to safely take total weight lifted, *e.g.*, in this case if we lashed the top block to the spar with 2 in. rope each turn = 2 ropes = 8 cwt., so four turns would be required.

MILITARY BRIDGES.

Two conditions must be fulfilled by a military bridge:

(i) It must be strong enough to stand the traffic required.

(ii) It must not take a long time to build.

There are three distinct types of bridging which may have to be undertaken during the process of military operations:—

(i) *Ordinary road bridges.* These are usually restorations of existing bridges which have been damaged or destroyed, and will take the form of either *trestle*, *frame*, *suspension*, or *tension* bridges.

(ii) *Floating bridges*, made of boats, pontoons, rafts, etc.

(iii) *Restorations of railway bridges.*—For these, trestles are generally used, but they require special and solid construction, and skilled labour.

The following terms are used in connection with military bridging, and must be noted. (Fig. 5, Plate XXIX.)

Baulks or *road-bearers* are strong beams running from pier to pier in the direction of the bridge, resting upon the transoms. Upon them are laid—

The chesses, or planks which form the roadway.

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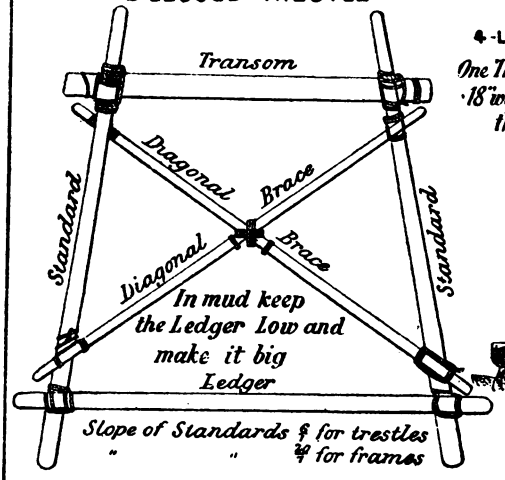
Fig. 1.

2-LEGGED TRESTLE

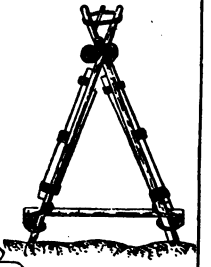


Slope of Standards $\frac{1}{8}$ for trestles
" " $\frac{1}{10}$ for frames

Fig. 2.

4-LEGGED TRESTLE

One Trestle to be 18" wider throughout than the other.



3-LEGGED TRESTLES

Fig 3

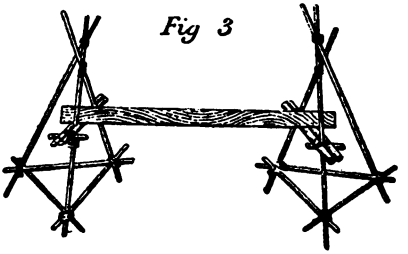
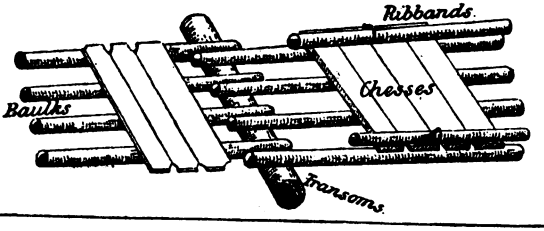


Fig. 4.

Fig. 5.

ROADWAY.



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A bay is the distance bridged by one set of baulks, not often more than 10 or 15 feet in a military bridge.

Camber is the slight rise generally given to the centre of a bridge to allow for subsequent settlement. It is usually $\frac{1}{60}$th of the span. In a long trestle bridge it would be sufficient to slope the ends of the bridge upwards at $\frac{1}{30}$ for about 30 ft.

Ribands are beams laid down each side of the roadway, and lashed by rack-lashings to the baulks. They stiffen the bridge, and act as kerbs to prevent wheels, etc., from slipping over the edges.

Width in the clear means the clear width of roadway inside the ribands. Eight feet in the clear is wide enough for all guns and wagons, for cavalry in half sections, or for infantry in fours; 16 ft. is the minimum width for a double row of carts; 6ft. will take cavalry in single file, infantry in file, or guns drawn by hand, and $1\frac{1}{2}$ to 3 ft. will take infantry in single file; 9 ft. in the clear, *i.e.*, inside to inside of ribands is the normal width of a bridge for all arms.

The different parts may be fastened together with rope, wire, bolts or nuts, spikes, etc.

Wire lashings are much better than rope.

In the construction and passage of all bridges, there are certain precautions to be taken to prevent confusion and accidents. The approaches to it *on both sides* must be easy, for it is evident that easy access, and difficult exit, must cause crowding on the bridge. If the bridge is approached by ramps, they should not exceed one in seven. One in 10 is much to be preferred, particularly for carts, animals, etc. The designers of the bridge are responsible that it is strong enough to bear the troops for which it is intended when *crowded*. Every bridge should be marked with the greatest load permissible on it.

A good handrail is a point often omitted when constructing bridges for practice, but it is an essential when animals have to pass over a high bridge. Very often it will be necessary to make high screens to prevent animals

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seeing over the sides. The roadway must also be prepared with litter, gravel, etc., and it is a good thing to have chesses on the ground some distance before the bridge so that animals may get accustomed to the noise.

The following rules for troops crossing military bridges, fords, etc., are extracted from Field Service Regulations, Part I:—

(i) An officer is posted at the approach to the bridge to give units instructions on special points to be observed in crossing.

(ii) An officer from each unit remains on rear side till the whole unit has passed to prevent unnecessary delays and spreading out.

(iii) Break step on the bridge. Files or sections not closed up.

(iv) If necessary to halt on floating bridges, guns, and wagons must halt as nearly as possible midway between two piers.

(v) Halt if bridge sways dangerously.

(vi) All horses should be dismounted when crossing, and be led across except those ridden by drivers who should remain mounted. Mounted men who have crossed are not to increase the pace for some distance after crossing.

CALCULATIONS FOR ROAD-BEARERS AND TRANSOMS.

The following are the maximum loads *per lineal foot of the bridge* which are brought on it by the passage of troops in marching order:—

Infantry in file, *crowded* at a check ...	$2\frac{1}{2}$ cwt.
Infantry in fours, *crowded* at a check	5 ,,
Cavalry in single file	$1\frac{3}{4}$,,
Cavalry in $\frac{1}{2}$ sections	$3\frac{1}{2}$,,

A bridge which will carry infantry in fours crowded, will carry any of the field guns and carriages which ordinarily accompany an army.

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Guns of position and howitzers want special consideration. The weight on the wheels, being a *concentrated* weight, has twice as much effect on the *road-bearers* as the same *distributed* load, *e.g*, a 4.7 in. Q.F. gun on travelling carriage has 85 cwt. on the gun wheels = 170 cwt. distributed load.

The transom is not affected by the load being concentrated on the road-bearers, as the road-bearers distribute the weight along it.

The Manual of Military Engineering contains a table showing number and size of baulks for various spans and loads, and suggests suitable sizes for the transoms. Such a table is intended to save calculations.

For students wishing to make calculations for themselves, the following examples will show the method of using the rough rule of thumb laid down in the Manual of Military Engineering:—

Example 1.—A bridge is to take infantry in fours crowded. How many 6 in. diameter fir road-bearers are required for a 12 ft. span?

$12 \times 5 = 60$ cwts. weight of infantry on one span.

A 6 in. fir road bearer will safely bear $\frac{6}{10} \times \frac{6^3}{12} \times \frac{5}{4}$ cwts. on a 12 ft. span.

Using rule W cwts. $= \frac{6}{10} \frac{D^3}{L} \times K$

$= 13\frac{1}{2}$ cwts.

Hence number of road bearers required $= \frac{60}{13\frac{1}{2}} + 1 = 6$, as the two outer road bearers only do half their share of the work.

Example 2.—How large should the transom be?

The transom has a span of 10 ft. 6 in. or 1 ft. 6 in. more than the 9 ft. roadway. Call D the diameter of the transom.

$$\frac{6}{10} \frac{D^3}{21} \times 2 \times \frac{5}{4} = 60$$

$D^3 = 840$ or D = a little over 9 in., say 10 in.

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Example 3.—What alterations have to be made to road-bearers and transom to admit of 5 in. field howitzers and their ammunition wagons passing over the bridge? Heaviest load on any pair of wheels 30 cwt.

The 30 cwt. is a *concentrated* load so = 2 × 30 cwt. = 60 cwt. distributed load, or same weight as Infantry.

The guns, etc., only bring 30 cwt. on the transom, or less than the infantry.

The bridge is therefore strong enough as it is.

Example 4.—4·7 in. guns on travelling carriages have to be taken across the bridge, what alterations are necessary? Weight 85 cwt. on gun wheels.

85 cwt. concentrated load = 2 × 85 cwt. = 170 cwt. distributed load.

6 in. road bearers would be hard to arrange as we should require $\frac{170}{13\frac{1}{2}} + 1$ per bay, or 14.

These and next bay overlapping would mean 28 which would not fit in. Larger road bearers would have to be used, say 8 in. fir, each of which will take

$$\frac{6}{10} \times \frac{8^3}{12} \times \frac{5}{4} \text{ cwts.} = 32 \text{ cwt., and we shall require}$$

$$\frac{170}{32} + 1 = 7 \text{ road bearers.}$$

For transom 85 cwts. is the distributed load, and as before in Example 2.

$$\frac{6}{10} \times 2 \times \frac{D^3}{21} \times \frac{5}{4} = 85.$$

$$D^3 = 1{,}190 \text{ or } D = 11 \text{ in.}$$

Special precautions will have to be taken to make sure each road-bearer does its work by having strong chesses that will distribute the weight of a gun wheel. The roadway where the gun wheels come will have to be double chessed.

Example 5.—How could a transom for Example 4 be made out of 12 in. by 2 in. fir timbers?

Strength of a 12 in. × 2 in. fir timber on edge =

$$\frac{2 \times 12 \times 12 \times 2}{21} \times \frac{5}{4} \text{ cwt.} = 34 \text{ cwt.}$$

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Three timbers bolted together would make a transom strong enough.

Chesses, planks, etc., may often be utilised for this purpose.

APPLICATION OF DIFFERENT TYPES OF BRIDGES.

When bottom can be touched throughout, a trestle bridge will generally be the most economical of material, and the easiest of construction.

If the gap to be bridged partakes of the nature of a chasm, and has no available bottom, a frame bridge must be used. If timbers of sufficient length for a frame bridge are not available, recourse must be had to tension or suspension bridges.

When deep water has to be crossed, of course floating bridges must be constructed.

Sometimes two or more types may have to be combined in the same bridge.

TRESTLE BRIDGES.

Trestles are of three kinds: two-legged, three-legged, and four-legged. They can be used separately, or in combination. An ordinary two-legged trestle (Plate XXIX.) is almost identical with the frames used in making single and double-lock bridges. It is kept upright in its position in bridge by lashing the road-bearers to the transoms, and by cross-bracing from each trestle to its neighbour. The trestles next the shore are rigidly connected with the banks, with light spars lashed to the standards, and to bollards on the banks.

Three-legged trestles are made by lashing two legs together with a sheer lashing, and afterwards adding the third leg, or like a gyn. The trestle is then up-ended, the feet are placed at the angle of an equilateral triangle with sides equal to about half the height, and three light ledgers are attached. These three-legged trestles utilise

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light material; they stand without bracing; and they admit of easy adjustment of the level of the roadway. On the other hand, they are unsuitable for an uneven bottom, and they are very difficult to place in position except by hand. (Fig. 3, Plate XXIX.)

The four-legged trestle is made by joining two two-legged trestles together. (Fig. 2, Plate XXIX.) It is useful in a small bridge of two bays requiring one central support, or as an occasional steadying point in a long line of two-legged trestles.

Carts, piles of sleepers, or stones, brushwood cylinders weighted with stones, etc., etc., may take the place of regular trestles.

When working over water trestles may be placed—

(i) By carrying them out to the bridge-head, pushing out the tops by handrails and sliding the feet down inclined spars. The feet are restrained by foot-ropes.

(ii) By floating them out to the bridge-head. Lifting up the tops and fixing handrails. Pushing on the handrails and hauling on foot-ropes from the bridge-head will then get the trestle up.

(iii) Placing them from *anchored* rafts. Guys and foot-ropes on the rafts and bridge-head control the trestle.

Three and four-legged trestles are best placed as in (iii). The feet require weighting. A tripod trestle should have three foot-ropes and three guys fixed to it.

General remarks.—Trestle bridges are applicable to shallow rivers whose beds are sound and firm, and which are not subject to sudden floods. They require but little timber in comparison with other bridges, and there is no limit to their length. Before making a trestle bridge, a section of the river must be made to determine the length of the legs of the various trestles which will be required.

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TAKING THE SECTION OF A GAP.

Before proceeding with the construction of a bridge, a section of the gap must be measured and laid out with pegs on convenient flat ground on either side of the gap where the trestles, etc., can be constructed.

First fix the exact positions and heights for the shore transoms, and if the gap is not too wide stretch a string across and on it. Mark with chalk or string where each pier or trestle will come. With rods placed successively under these marks, the vertical height of the ground below them can be measured.

A straight line of length equal to the distance between the shore transoms is laid out on the ground, each point on it where the piers or trestles are to come is also marked and the vertical heights referred to above measured at right angles to the line.

When these are pegged out the section of the gap is thus depicted on the flat ground.

If part of the section is over water, soundings must be taken under the position of each trestle. Giving the proper camber, the line of the roadway can now be shown on the ground.

Each party constructing a trestle can then ascertain from the section, the exact length of each leg required, and where to lash their transom, deducting the thickness of roadbearers and chesses from the height of roadway to ground, and also making allowance for any splay outwards in the legs. The most practical way to ascertain the latter is to lay out by eye on the ground a right-angled triangle, pegging out along one side the length from ground to top of transom, and along the other side pegging out the length of splay, *i.e.*, if former is 9 ft. and splay is to be $\frac{6}{1}$ this length will be $\frac{9}{6}$ ft. or 18 in.

Place the leg over the two pegs with its foot against one peg and chalk mark it at the other peg as the place to lash the transom.

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FRAME BRIDGES.

There are four kinds of frame bridges:—

(i) The single lock, for spans up to 30 ft.
(ii) The double lock, for spans up to 45 ft.
(iii) The single sling, for spans up to 60 ft.
(iv) The treble sling, for spans up to 80 ft.

The span is measured between the footings of the frames. All frame bridges require large and heavy spars.

The two last-named kinds of bridge require spars of exceptional length (40 ft. and upwards) and weight, and will not be further referred to here, as their use is very unusual.

Firstly.—In making a single, or double-lock bridge, the first step is to mark out on the bank an exact full-sized section of the gap to be bridged, and to prepare *footings* (18 ins. wider apart on one side than the other if for a single-lock bridge). If the footings are not correctly square the bridge will not lock.

Secondly.—Lay out the standards on the section, and on them chalk-mark the proper positions for lashing the ledgers and transoms.

Thirdly.—Lash the frames in position on either side of the gap, making one frame 18 in. narrower than the other, if it is a single-lock; but both of equal size, if it is a double-lock.

Fourthly.—The frames being ready, fore and aft guy ropes are attached to them, and foot-ropes to the butts of the standards, which are then carefully lowered until they rest in the footings previously prepared.

If it is a single-lock bridge, the frames are now hauled over until they meet and lock, care being taken that the horns of the narrow frame are both inside the horns of the wide one. A transom is then hauled out, and laid in the fork, and the road-bearing baulks are next laid from the shore to it. Finally the roadway is put down, and secured with ribands, and a hand-rail rigged up.

If it is a double-lock bridge, the frames are not hauled over till they meet, but held back from each other by the

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guy ropes, while two beams (the distance pieces) are hauled out and laid resting on them. Two transoms are then sent out, and lashed (at marks previously made at the correct positions) on the distance pieces, after which the guys are eased off and the bridge allowed to lock. The roadway is then laid as usual.

For a single-lock bridge, span 30 ft., the following spars are required:—

4 Standards, about 22 ft. each—7 in. at tip.
2 Transoms, about 15 ft. each—6 in. mean diameter.
2 Shore transoms, 15 ft. each—4 in. to 6 in. mean diameter.
1 Fork transom, 15 ft.—10 in. mean diameter.
2 Ledgers, 15 ft. each.—4 in. to 6 in. mean diameter.
4 Diagonal braces, about 20 ft. each—3 in. at tip.
10 Baulks, or roadbearers, 20 ft. each—6 in. mean diameter.
4 Ribands, about 20 ft. each—3 in. at tip.

and a quantity of planks, ropes, or wire, etc., etc.

FLOATING BRIDGES.

The site for a bridge should be near the main line of communications, and the approaches to it short and easy. If they run across soft or marshy ground it will give a lot of trouble. The bottom should afford good anchorage. The near bank should, if possible, command the far bank, and should afford cover, while the far bank should be open and exposed. In any case marshy banks should be avoided.

Islands should be utilised when available, as they help to conceal preparations, and economise material, while the shorter a bridge, the stronger it is.

Affluents are often useful in the same way.

A re-entering bend of a river is good for the construction of a bridge from a tactical point of view, but may not be so good from an engineering point of view, as the

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depths at such places are always variable, and an oblique strain is brought on the piers by the current instead of a direct one.

When the depth is very variable, a sudden fall in the water is apt to ground some of the boats, and break them by the sudden extra strain thrown upon them. Therefore, straight reaches are preferable to bends, as the depth of water is more generally uniform in them.

NOTE.—Many of the foregoing considerations apply equally to fixed bridges.

In reconnoitring a river with a view to effecting a passage, the following, then, are some of the points that must be observed:—

(i) The nature of the banks; whether steep or shelving; whether one commands the other or not; whether they are open, wooded, marshy, etc.

(ii) The nature of the bed of the stream; whether it is mud, gravel, or sand, etc.

(iii) The velocity of the current, and whether the river is a tidal one or not.

(iv) The position and depth of fords.

(v) The width of the river generally, and at particular points.

(vi) The probability and extent of floods.

(vii) The distance from the main roads of points considered suitable for passage, and the nature of the approaches to them.

(viii) The existence, or otherwise, of tributary streams, or islands, which might facilitate, or conceal preparations, etc., etc.

Fords.—The following depths are fordable:—

3 ft. by infantry; 4 ft. by cavalry; 2½ ft. by artillery. Fords should be clearly marked out by long stakes driven into the river bed above and below them, their tops being connected by a strong rope. The stakes should be marked, so that any rise in the water may be at once noted. If

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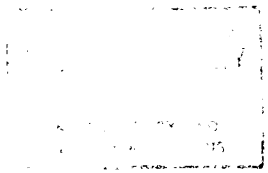

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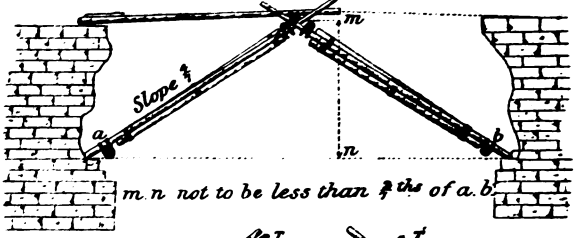
LOCK BRIDGES.

Fig. 1.

SINGLE LOCK.



m n not to be less than ¾ths of a b

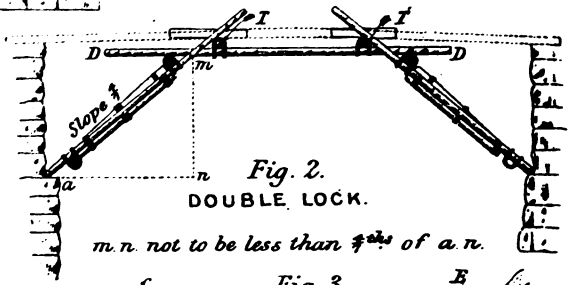


Fig. 2.

DOUBLE LOCK.

m n not to be less than ¾ths of a n.

Fig. 3.

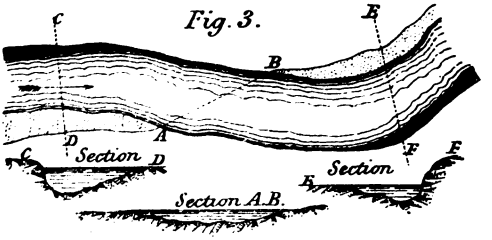
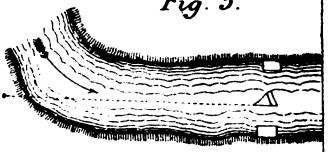


Fig. 4.

Fig. 5.



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a ford has a sandy bottom, its depth will increase with use, as the sand gets stirred up, and carried away by the current. A gravel bottom is therefore best. A river is often fordable obliquely between two bends, when it cannot be forded perpendicularly across anywhere. (See Plate XXX.) This is because the current scoops out a deep channel for itself at each bank that it strikes against, leaving the water at the opposite bank comparatively shallow.

The velocity of the current may be determined by throwing a branch into the stream and seeing how long it takes to float, say, 100 yards. Or, note the distance it floats in a given number of seconds, then $\frac{7}{10}$ths of the number of feet per second will give velocity in miles per hour.

Ferries and flying bridges.—The simplest kind of ferry consists of a rope stretched from bank to bank, by means of which a boat or raft can be hauled backwards or forwards.

If this is not feasible, *a flying bridge* may be arranged, *i.e.*, a boat which is anchored in the stream and made to cross from side to side by the stream acting obliquely against its side which should be kept at an angle of about 55 degrees with the current.

Long, narrow, deep boats, with vertical flat sides, are the best for this purpose; and straight reaches the most suitable places, as they are the most free from backwaters, etc.

The cable by which the boat is moored should be $1\frac{1}{2}$ to twice the breadth of the river, and must be buoyed to prevent its dragging in the water. It can be anchored in mid-stream, or two cables may be used, one being anchored on each bank, but this method necessitates two cables, and four landing piers. (Plate XXX.)

GENERAL PRINCIPLES.

The piers of all floating bridges must satisfy the following three conditions:—

(i) The buoyancy must be sufficient to support the heaviest load that can come on any pier.

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The *actual* buoyancy must be multiplied by some factor of safety. With closed vessels like casks, decked-in boats, etc., nine-tenths of the actual *buoyancy* may be taken as *available* buoyancy. With headless casks, open boats, etc., only about two-thirds of the actual buoyancy would be available.

Timber liable to be water-logged about five-sixths.

(ii) The length of pier must be at least twice the breadth of the roadway to give it stability.

(iii) Unless in a perfectly still waterway the breadth of the piers must not exceed the clear waterway between them, otherwise the bridge is liable to be swept away.

Anchors.—Anchors of various weights, 56 lbs., 112 lbs., etc., are articles of store; also 3 in. cables for them. The length of cable "out" should be at least ten times the depth of the stream, and rarely less than 30 yards. It is usual to buoy anchors to mark their position exactly.

Make-shift anchors can be made of two pick-axes lashed together; or of heavy stones, or bent rails, etc. Nets filled with stones are remarkably effective on rocky bottoms. It may often be possible to anchor the piers to a cable some way up stream stretched from bank to bank.

In tidal rivers piers must be moored at both ends, boats, etc., alternately bow and stern upstream.

Only casks and barges will stand grounding with a weight on them. In tidal rivers with gently sloping banks bear this in mind if a bridge has to be used at all states of the tide.

BOAT BRIDGES.

To find the buoyancy of a boat, and the intervals at which they may be safely placed in the bridge:—

Fill the boat with unarmed men till the water is 12 in. from the gunwale. Then the number of men multiplied by 160 will give the available buoyancy in pounds. And the number of men divided by four will give the central

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interval in feet at which the boats may be placed to carry infantry in fours crowded.

To allow for undulations, and also because few boats are strong enough to allow of the baulks resting on their gunwales without breaking them, a central transom should be arranged in each boat with a bearing on the keel. The road bearers will rest on this transom, which will be a little above the line of gunwales. The usual way is to pile up planks on the seats and secure them from shifting, the seats being strutted on to the keel.

Boats are very hard to fit up as piers in accordance with the general principles enumerated above. Their buoyancy is small compared with their length, and two boats side to side in a pier do not generally give enough waterway, while placed stern to stern they make an inconveniently long pier and one very difficult to construct.

Example.—A cutter 30 ft. long, 8 ft. wide, will contain 60 unarmed men when loaded to within 12 in. of the gunwale. How can it be used as a pier in a normal floating bridge?

The maximum span is 15 ft., *viz.*, $\frac{60}{4}$, for which one cutter is suitable. This only gives 7 ft. waterway. If span was increased two cutters could be lashed stern to stern, and connected rigidly together by a framework of spars, with ropes passed under the keels and secured to the framework, but such a pier would be 60 ft. long and hardly comes under the head of practical field engineering.

Probably the waterway would have to suffer, and extra precautions taken with the anchoring arrangements.

The cutter would, of course, form an excellent pier for a bridge to take any lighter weight than infantry in fours, *e.g.*, infantry in file.

CASK BRIDGES.

When casks are used for bridging purposes they should be carefully sorted. The large ones are of course the most

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useful for every reason. The casks can be lashed together as described below, to make a pier. These piers are put together on shore, and launched separately. They are then connected in pairs to tie-baulks, towed into position, and anchored, and finally the road laid over them.

To roughly determine the buoyancy of a cask.—Multiply the contents in gallons by nine. This will give rather less than the *available* buoyancy, but it is a good safe rule. For headless casks multiply gallons by 6½.

Piers of casks must satisfy the general principles already enumerated, which can usually easily be arranged by a little consideration.

The easiest way to make a pier with large casks is:—

Find out how many casks are required to provide the necessary buoyancy, say N casks. Place the casks in a row, side by side, bungs uppermost. On them lay two spars, called gunnels, about 6 in. from their ends. Then fasten slings to one end of each gunnel, pass them under all the casks, and bring them up, and secure them to the other ends of the gunnels. Next two N—2 small ropes, called braces, are fastened to these slings, half on each side in the intervals between the casks.

Each brace is now brought up, turned once round its own gunnel, passed over to the opposite side, and round the opposite brace, then brought back to its own side, hauled tight, and finished off round its own gunnel.

It requires 2 N + two men to make a pier of N casks properly.

With medium casks the casks may be placed end to end in two rows side by side. Three spars are wanted—one to form an artificial keel between the rows of casks, and two on top of the rows of casks. Two braces per cask are then fastened to the bottom spar passed round outside the casks and secured to the top spars. The spars are finally windlassed together, and every precaution taken to prevent the barrels from casting loose.

With *small casks* piers may be made as above described, and three or four piers joined together to make one large pier.

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Headless casks are best enclosed in a specially prepared framework. Earthenware jars are sometimes available, and would best be placed mouth downwards.

The following examples will illustrate the application of the three general principles applied to piers of casks.

Example 1.—Make up a pier of 108 gallon casks suitable for normal bridge, and determine suitable spans for such piers.

Turning to the table of dimensions of casks in Manual of Military Engineering, we find a 108-gallon cask is approximately 4 ft. long and 2 ft. 9 in. bung diameter. Bays must be at least 8 ft. span to give clear waterway if casks are made up side by side. Pier must also be at least 18 ft. long to give stability.

Seven casks give a length of 7×2 ft. 9 in. $= 19$ ft. 3in., and have a buoyancy of $7 \times 9 \times 108$ lbs. $= 60$ cwt. approximately.

Now infantry crowded in fours weigh 5 cwt. per ft. run, and superstructure about 1 cwt., making a total of 6 cwt. per ft. run, so a pier of seven casks has buoyancy for a 10 ft. span and the clear waterway is greater than the width of the pier.

Example 2.—Make up a pier of 54-gallon casks as in Example 1. A 54-gallon cask is 2 ft. 9 in. long and 2 ft. $4\frac{1}{2}$in. bung diameter. (See Manual Military Engineering.)

Here we can act in two ways. (i) Make up piers as in Example 1 of casks side by side.

$$\text{Pier must be } \textit{at least } 18 \text{ ft. long and } \frac{18 \text{ ft.}}{2 \text{ ft. } 4\frac{1}{2} \text{ in.}} = 8 \text{ casks (19 ft.)}$$

Eight casks only give a buoyancy of $8 \times 9 \times 54 = 36$ cwt. or a span of less than 6 ft., which is very small and inconvenient.

Two piers joined together give a buoyancy of 70 cwt., or a span of 11 ft. 8 in., and clear waterway 6 ft. 2 in., and width of pier 5 ft. 6 in.

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(ii) Make up piers of casks joined end to end. Seven casks give a length of 7×2 ft. 9 in. $= 19$ ft. 3 in., and 14 casks give a buoyancy of 60 cwt., so 10 ft. spans will suit. The clear waterway is 5 ft. 3 in., and width of pier 2×2 ft. $4\frac{1}{2}$ in. $= 4$ ft. 9 in.

Obviously the question of concentrated and distributed loads does not affect *buoyancy*. The calculations for the road-bearers of floating bridges are just the same as for other bridges.

RAFT BRIDGES.

Raft bridges are made of trunks of trees, or other large logs. Their disadvantages are that they have a low buoyancy, and soon get water-logged; they are heavy and clumsy; obstruct the waterway more than other structures; and take a long time to build. On the other hand, they can be put together by unskilled workmen, and are practically unsinkable. They are not adapted to streams with a rapid current, as the strain would be so great on the bridge that it would be almost impossible to anchor the rafts securely.

The rafts are generally put together in the water. Large logs are first laid thick and thin ends alternately, and secured together. If additional buoyancy is required others can be placed in the intervals of the first lot. They are secured by lashings, braces, etc. The up-stream end of the raft should be roughly bow-shaped to lessen the strain on the bridge. A centre raised transom must be used with each raft. When the rafts are in position, the roadway is laid down as in any other kind of bridge.

The buoyancy of a log is found by subtracting its weight from the weight of a volume of water equal to the contents of the log. Take $\frac{5}{6}$ths of this as available buoyancy. Water weighs $62\frac{1}{2}$ lbs. per cubic foot.

Example.—Find the buoyancy of a pine log 20 in. mean diameter and 30 ft. long.

Contents of the log are approximately $\frac{22}{7} \times \left(\frac{10}{12}\right)^2 \times 30$ cubic feet $= 65$ cubic feet.

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Weight of 65 cubic feet of water = 65 × 62½ lbs. = 4062½ lbs.

Weight of the log (see Manual Military Engineering) = 65 × 40 lbs. = 2600 lbs.

Available buoyancy of the log = $\frac{5}{6}$ × 1,462½ lbs. = about 1,200 lbs. or little more than a 108-gallon cask.

GETTING A FLOATING BRIDGE INTO POSITION.

Bridges can be made in four ways:—

(i) By booming out.
(ii) By forming up.
(iii) By rafting.
(iv) By swinging.

In booming out, as the head of the bridge is finished, it is pushed out into the stream, and material continually added to the tail until the far bank is reached. This method cannot be used when the banks are steep, and the water inshore deep, because to carry it out some men must work in the water. It has the advantage of saving labour, inasmuch as the materials for the bridge have not got to be carried across it.

In forming up, the tail of the bridge remains stationary, and material is constantly added to the head. The only drawback to this method is the distance the materials have to be carried. Otherwise it is a good one, and uninfluenced by the nature of the banks.

In rafting.—Each raft of two or more piers is prepared separately along the bank, and afterwards towed into position. The special advantages of this method are that a large number of men can work at once, and it favours secrecy where secrecy is a matter of importance.

In swinging, the whole bridge is completed in every respect alongside the bank, and then swung across with the stream.

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CHAPTER XIV.

HASTY DEMOLITIONS.

Hasty demolitions may be effected by means of gunpowder, gun-cotton, axes, crowbars, fire, etc.

Gun-cotton is about four times as powerful as gunpowder, weight for weight, when the powder is not tamped. But if it is tamped, then there is only about 2½ times the difference in favour of gun-cotton.

Tamping a charge means covering it over well with earth, etc., so as to confine the gases at the commencement of the explosion, and more fully develop their force.

Gun-cotton for service is issued in *discs* and *slabs*. The discs are each 1 oz. in weight, the slabs 15 ozs. In each disc a hole is ready bored for the reception of the detonator, by means of which it is fired. In each slab there is one hole to receive the primer, and through which string can be threaded by which several slabs can be carried all together more conveniently. If a light is applied to dry gun-cotton, it will burn with a yellow flame, but will not detonate. The discs are carried in the field *dry*, but the slabs are carried *wet*, in wooden water-tight boxes. The explosive force of wet gun-cotton is even greater than that of dry, but a small quantity of *dry* gun-cotton must be used as a primer, and this must be in *immediate contact* with some powerful detonating substance like fulminate of mercury.

Cordite is sometimes available. It wants a very strong primer or primers, as it is very apt to simply burn. Otherwise it may be treated like gun-cotton.

Precautions in firing gun-cotton:—

1.—Test your detonator and fuze by taking a sample from the tin.

2.—The *primer* must be thoroughly dry.

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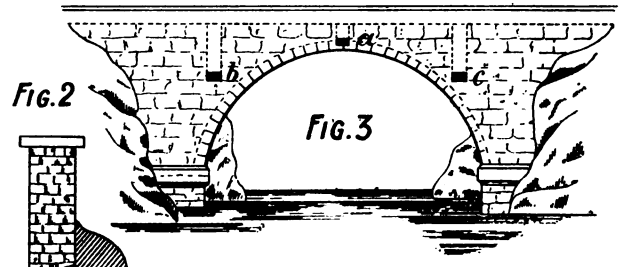
HASTY DEMOLITIONS.

FIG.1 DETONATOR.



Continuous plate girder

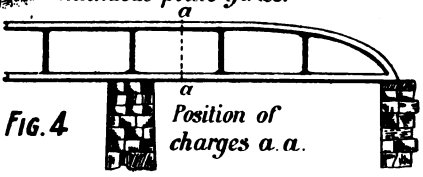
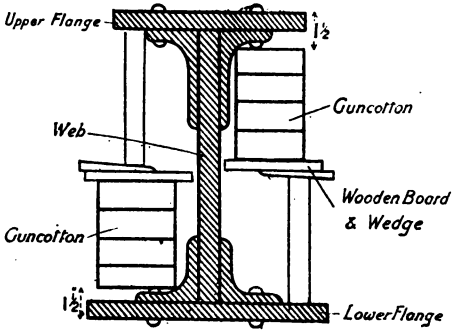


FIG. 3



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3.—The charge must be in *close contact* with the object to be demolished.

4.—The fuze must be inserted well home into the tube of the detonator, and secured there.

5.—The detonator (described below) must be inserted so far into the charge that *the whole* of the fulminate in it is in contact with the gun-cotton.

6.—If the ready-bored hole in the gun-cotton is too small for the reception of the detonator, the latter is on no account to be screwed or forced in. The hole must be enlarged with an instrument called *a rectifier* provided for the purpose.

7.—Great care must be taken that the spark from the fuze does not set light to the gun-cotton before it is exploded. To guard against any chance of this it is well to cover the charge over with a handful or two of earth or a damp sand-bag, etc., etc.

8.—Gun-cotton charges must extend continuously and be evenly distributed across the *whole* width of the breach or cut required.

9.—If a miss-fire occurs, give it at least 20 minutes, and remember the fuze may be smouldering, so if you try and draw it use plenty of water. It is often safer to leave the charge alone and kill it with a fresh charge.

The detonator used in connection with fuze is a brass tube painted red, containing fulminating composition at its pointed end. Next to this comes a wooden plug in which is held a piece of quick-match, and the rest of the tube is empty, and open at the bottom. When required for use, a piece of Bickford's fuze is cut to the required length, and inserted into the hollow end of the detonator, care being taken to push it well down, so as to rest on the quick-match. The tube is then slightly bent to prevent the fuze from falling out. The detonator is then placed in the charge, and is ready for firing. (Fig. 1, Pl. XXXI.).

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Cavalry Pioneers are supplied with detonators, and fuze ready fixed, the fuze having a piece of quick-match added to the end to facilitate lighting.

Fuze.—There are two kinds:—

The ordinary fuze and the instantaneous fuze.

The ordinary fuze consists of a train of gunpowder enclosed in two coatings of jute thread twisted in opposite directions, and water-proofed and strengthened by layers of tape, gutta-percha, etc.

Its usual rate for burning is about 3 ft. a minute. The safest way is to take a sample from the tin and time its rate of burning.

The instantaneous fuze consists of quick-match enclosed in several layers of tape, gutta percha, etc. It is quite damp and waterproof, and is known from the ordinary fuze by being coated with an open crossed snaking of orange-coloured worsted.

It burns at the rate of 30 *yards per second.*

Both the above fuzes can be used through water.

To join two pieces of instantaneous fuze.—Bare short lengths of the quick-match, twist them together, and wrap round with paper, tape, etc., or anything that will make a water-proof joint.

The ordinary and instantaneous fuzes are often used together. In joining them, both fuzes are cut in a slant. If available, a little powder or quick-match may be placed between the fuzes, and then they are fastened together by wrapping round the joint with string, and using a small piece of wood or a match as a splint. The joint can be made waterproof if required. Three or four charges may be sent off together by using three or four *equal* lengths of instantaneous fuze connected to the charges, and the other ends led into a small bag or tin full of powder, or powdered dry gun-cotton. A piece of safety fuze with one end in this tin will then ignite all the other fuzes.

Powder hose is used sometimes when fuze is not available. It is made of strips of strong linen sewn together,

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making a piping of about half-an-inch or an inch in diameter, which is filled with gunpowder. It is generally made up in lengths of 10 to 20 ft. for convenience in filling, and burns at the rate of 10 to 20 ft. per second.

Gunpowder charges to demolish stockades, etc. :—

1.—The charge should be in a compact shape, *i.e.*, convenient for carrying.

2.—It should, whenever practicable, be *well tamped*. Sand-bags full of earth for tamping may be carried by the party; but they must be different to those in which the powder is carried, otherwise mistakes may be made.

3.—The charge may be carried in leather bags (articles of store) or in tarred sand-bags, each sand-bag being covered with a second one similarly tarred, so as to prevent all chance of a spark prematurely igniting the charge.

4.—The end of the fuze must be inserted well into the middle of the charge, and care taken that it cannot be accidentally pulled out.

5.—Every man of the party should have about him the means of firing the fuze; and spare men should be detailed to carry the various stores in case of accident to those first told off for the purpose.

ARRANGEMENT AND CALCULATION OF CHARGES.

It is not necessary to remember formulæ, but one must know how to apply them.

The Manual of Military Engineering gives the formulæ required for most classes of demolitions. These formulæ represent the minimum amount of explosive to be used. With gun-cotton charges, the eighth condition on p. 209 has to be observed, and it is often necessary to *increase* the charge to admit of its extending continuously across the whole width of the breach, for, as

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a general rule, the slabs should not be cut, but used whole. The way to go to work is:—

(i) See what the formula makes the charge.
(ii) Arrange the charge to fit the slabs and come as near the formula as possible.

It is necessary to bear in mind the dimensions of the ordinary service forms of gun-cotton:—

15 oz. slabs are 6 in. × 3 in. × $1\frac{1}{2}$ in.
A 1 oz. primer is $1\frac{1}{4}$ in. diameter, and $1\frac{1}{4}$ in. high.
When the primer is inserted the slab becomes exactly 1 lb.

Gunpowder charges are simpler, as it is merely a question of dividing the total charge up into a series of equal charges at intervals of about twice the thickness of the object attacked.

The *tamping* should be at least $1\frac{1}{2}$ times this thickness.

TREES, &c.

Auger holes are the most economical method. The centre of the charges should be in the centre of the tree. Formula $\frac{3}{8}$ T^2 lbs. A tree 12 in. diameter requires $\frac{3}{8}$ 1 lb. = 6 oz. 3 2 oz. primers = 3 × $1\frac{3}{8}$ in. long = 4 in. approximately, so the auger hole should be bored 8 in. into the tree. If all the charge cannot be got into one auger hole, two or three auger holes may have to be bored. In a large tree, there will be considerable difficulty in making these meet. With electrical means of firing available this would not be of much importance. If detonators are plentiful, it may be better to bore only one hole at a time, and fire the charge in it; then bore another hole in the uninjured part of the tree and explode another charge in that; and so on until the tree falls. By fastening a rope to one of the upper branches, and taking strain on it before firing the charge, a tree may be made to fall in any required direction.

A *necklace* of primers makes a clean cut, but is so extravagant in gun-cotton that it is hardly worth con-

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sidering in the field. Formula 3 T^3, or 3 BT^2. It is necessary to make sure the charge from the formula will go right round the tree. A necklace would not act for trees larger than 12 in. diameter.

Example. A 12 in. tree would require 3 lbs. for a necklace = 48 1 oz. primers.

The circumference is about $3\frac{1}{7}$ ft. and 48 1 oz. primers = 48 × $1\frac{1}{4}$ ins. = 60 ins. or 5 ft., so charge will more than go round and will suit.

A slab in a single charge may also be used, formula 3 BT^2, or 3 T^3 = 3 lbs.

Wooden bridges.—Apply the rules given for cutting down trees with gun-cotton. The uprights of the piers are the best parts to attack.

Axes, oil, and fire may also be brought into play in the destruction of a wooden bridge.

STOCKADES, ETC.

Gunpowder charges have already been dealt with. The Manual of Military Engineering indicates the approximate amounts of single charges suitable for various types.

The most convenient way to place a gun-cotton charge against a stockade, so as to ensure contact between the slabs, is to tie them beforehand on to a board, and to carry this up with the gun-cotton attached; a hole must be cut in the board for the detonator and fuze.

The board is placed with the gun-cotton next the stockade, and two pickets can be driven into the ground to keep it there, or a couple of nails driven into the stockade to which the charge may be hung.

Example.—To make a breach 6 ft. wide in a hard wood stockade of 12 in. timbers. Formula 3 BT^2.

$$\text{Charge} = 3 \times 6 = 18 \text{ lbs.}$$
$$\text{No. of slabs} = 18 \times \tfrac{16}{15} = 19.$$

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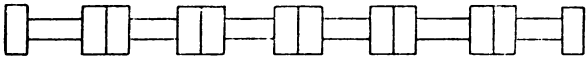
It would be advisable to take 24 slabs in this case, distributing 12 slabs lengthways, covering six feet of the stockade, and 12 slabs over them.

If the supply of gun-cotton slabs was limited, the following distribution might be adopted—each slab to have a primer in it, in order to make it up to exactly 1 lb.:—



This arrangement would take exactly 18 lbs., *i.e.*, 18 slabs and 18 primers, and fulfil the condition of even distribution sufficiently well as every linear foot would have 3 lbs. of gun-cotton and all in good contact.

WALLS.

Gun-cotton charges may be arranged and placed as already described in stockades. Formula $\frac{1}{2}$ BT^2. The charge should be equally distributed along the foot of the wall. If tamping equal to thickness of the wall be added, half the quantity obtained by the above rule would suffice. If the wall is very thick, a groove should be cut in it first to weaken it as much as possible. (Fig. 2, Pl. XXXI.). If the wall is 2 ft. thick only, or less, then 2 lbs. of gun-cotton per foot run will suffice. The length of the breach should not be less than the height of the wall to be brought down.

Example.—To blow down 10 ft. of wall 2 ft. 6 in. thick and 10 ft. high would require $\frac{1}{2} \times 10 \times (\frac{5}{2})^2$ lbs. = $31\frac{1}{4}$ lbs.—a little over 3 lbs. per foot run.

It would be advisable here to take 40 slabs ($37\frac{1}{2}$ lbs.); this would give four slabs per foot run, which are easily distributed evenly along the wall.

With gunpowder the formula is $\frac{3}{2}$ BT^2, so wall in above example would require $93\frac{3}{4}$ lbs. arranged in two charges of 47 lbs., 5 ft. apart, centre to centre, and

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charges would have to be tamped with at least 4 ft. of earth.

Houses may have the walls attacked in the manner described above if very strongly built.

Lightly built rooms may be brought down by shutting all the doors and windows and detonating about 4 lbs. of gun-cotton on the hearthstone or against the wall in a corner. Few houses would stand the shock of 10 to 15 lbs. of gun-cotton detonated against a hard surface like a hearthstone.

MASONRY BRIDGES.

In a single-arch bridge it is best to attack the haunches (*b*, *c*, Fig. 3, Pl. XXXI.), because the gap made will be bigger; but if time is pressing, the charge must be placed along the crown (*a*) of the arch. In either case, a trench equal in length to the width of the road is dug down to the point selected for the attack, and the charges laid in it.

Digging a trench down to the arch at the haunches will often take considerable time.

With gun-cotton, whether over the crown or the haunches, the charge will be $\frac{3}{4}$ T^2 × B if it is *not* tamped. If it *is* tamped, $\frac{3}{8}$ T^2 × B will suffice. The gun-cotton is made up as in the case of walls, the slabs touching the arch ring.

Example.—A road bridge 30 ft. wide is supported on a semi-circular brick arch 2 ft. thick. What charge of gun-cotton is required? Plenty of time is available.

The haunches make the most effective demolition. Charge—$\frac{3}{4}$ × 30 × 2^2 lbs. per haunch = 90 lbs. per haunch.

$$\text{Number of slabs} = 90 \times \tfrac{16}{15} = 96.$$

In this case it would be advisable to take 105 slabs, distributing 60 lengthways, and in contact along the haunch from side to side (30 ft.) and distributing the

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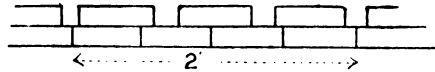
remaining 45 evenly on the top of them; the top layer will then be distributed with three slabs in every 2 ft., but will be in direct contact with the lower layer.



The formula for gunpowder is $\frac{3}{2}$ BT², and charge must be tamped.

Charge is therefore 180 lbs. per haunch, arranged in seven charges of 26 lbs., about 4 ft. apart, centre to centre.

If a bridge consists of a series of arches, and the piers are short and thick, the haunches should be attacked. If, on the other hand, the piers are high and thin, they should be attacked, as the fall of one pier will bring down two arches. Demolishing a pier with gunpowder would be rare.

For gun-cotton the charge for brick piers is $\frac{1}{3}$ BT² made up and placed as already described in walls.

IRON GIRDERS, PLATES, ETC.

Iron girder bridges may be destroyed by placing a charge under the supports, or the girder itself may be destroyed with gun-cotton, which is generally far quicker.

As a rule the best effect will be produced by cutting a girder near a point of support, and this course will be economical of explosive, as the flanges are usually slighter at the ends than at the centre. In the case of a girder continuous over several spans, the point selected should be in the first or last span, at the end away from the shore. (Fig. 4, Plate XXXI.).

If there is any doubt about the effect of one charge, the girder should be cut at each end of the span.

In girders with an open web, the top and bottom flanges should be cut. In girders with a plate web

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(unless this is very thin relatively to the flanges) both flanges and web should be cut. When there is a lack of explosive, the bottom flange is the most important to cut.

The formula for iron plates is $\frac{3}{2}$ B t^2, B being in feet, t in inches.

The following examples and Fig. 5, Pl. XXXI., will best explain how to arrange the charge for an iron girder with a thick plate web.

Example 1.—Plenty of explosive is available, and the girder in Fig. 5, Pl. XXXI., shows the section of *one* of the main girders of a road bridge at the point where it is desired to cut it. How should charges be arranged?

The thickness of the flange, as well as that of the metal over and under it and that of the bolt head, must be added together to obtain "t." In this case it is $1\frac{1}{2}$ in.

Each flange is calculated separately, and the charges arranged in diagonally opposite corners.

$$\text{Each charge} = \tfrac{3}{2} \times 1 \times (\tfrac{3}{2})^2 = 4 \text{ lbs.}$$

Total required, 8 lbs.

Two detonators are necessary, and unless the charges are fired by electricity, two equal lengths of instantaneous fuze ignited by a safety fuze. (See page 210).

Very often the web merely consists of open lattice work.

In this case one charge would be placed on the top of the top flange and the other under the bottom flange, both charges being lashed in position with wire or rope.

The charge for each flange must be calculated separately.

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RAILWAYS, ETC.

Railways should not be injured without special orders.

A railway may be temporarily disabled by removing rails or cutting them with gun-cotton. The charge should be fastened tight against the web of the rail near a chair and on the same side as the key.

Two-thirds of a lb. of gun-cotton is necessary to destroy heavy rails.

In practice one slab and one primer would be used (1 lb.).

Twelve 1-oz. primers (with the detonator in one of them) will also do, but is not so convenient to fix.

To remove a rail.—Unscrew the nuts from the bolts of the fish-plates, then knock out the bolts, and wrench up the rail (which is now only held down to the sleepers by spikes) with pick-axes.

To destroy a railway.—Remove the rolling stock. Tear up the rails and carry them away, or throw them into rivers or ponds. Burn the sleepers; set fire to the stations and fuel stacks; destroy the water supply, and blow up the bridges, etc.

Rails can be made totally useless by twisting them. This can be done by heating them to a red heat in a fire made of sleepers, and then taking a bearing of either end of them, in opposite directions, with pick-axes stuck into the fishplate bolt holes.

Blowing in a tunnel is a most effective way of stopping a line. Select points well inside the tunnel, and attack the haunches if they can be got at. It is better to blow in one long tunnel in several places, than several short tunnels in only one.

If it is not considered feasible to attack a point inside the tunnel, the entrance can sometimes be attacked by driving shafts parallel to the axis of the tunnel, along the haunches from the entrance face, and placing the charges on the haunches in the usual way.

Gunpowder is preferable to gun-cotton for this class of demolition, as it brings down more debris.

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Blowing in the lining only is of little use in hard soil. At least one day's work would be required to make much effect on a tunnel in hard soil.

Example.—In a chalk tunnel. To blow in a length of 32 feet, brick lining 18 in. thick, gun-cotton available.

Shafts would have to be driven into the soil along and behind the haunches. This is difficult, but the safety recesses found in most tunnels assist in starting these shafts.

$$\begin{aligned}\text{Charge for each haunch} &= \tfrac{3}{4}, \text{B.T.}^2 \\ &= \tfrac{3}{4} - 32\,(\tfrac{3}{2})^2 \\ &= 54 \text{ lbs.}\end{aligned}$$

It would be necessary, therefore, to use 64 slabs (15 oz. each), placed continuously along the haunch, each slab being 6 in. long, making a total of 108 slabs for the two haunches.

The example is given to bring vividly before the student's mind the difficulty of effectually blocking a tunnel for any length of time.

A line of telegraph should not be injured without special orders. To simply disable it, remove the instruments or scrape all the wires bright and clean, and bind them together with fine wire. This will occasion a very troublesome "fault."

To destroy the line, cut down the posts, cut the wires, break the insulators, and break or carry off the instruments and batteries.

Guns can be destroyed by placing charges of gun-cotton in the breech, first loading it up with a shell if possible, and then tamping it behind with sods of earth, etc., after the insertion of the fuze. The breech block should be swung to as far as possible.

The charge for 3-in. guns is 2 lbs. Double the charge for every inch increase in calibre.

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CHAPTER XV.

CAMPING ARRANGEMENTS.

Cooking.—A field kitchen is a narrow trench, end on to the prevailing wind. The camp kettles, etc., are placed on it in a row, and the spaces between them covered up with flat stones, clay, etc. The fire is started and fed from the windward end, and a chimney built up at the other end will increase the draught.

The *width* of the trench depends entirely on the kettles used, about 9 in. is the usual width for large service kettles.

The *depth* depends on the fuel, about 12 in. will usually suffice. The trench should slope *upwards* to the chimney to improve the draught.

The *length* depends on the number of kettles. The Manual of Military Engineering gives tables showing sizes of kettles, etc. A trench should not generally exceed 10 ft. in length or at most 12 ft. The trenches may either be dug out of the ground or formed by building up walls of stones, sods, etc.

A very good kitchen may be made out of the camp kettles themselves by forming the trench with kettles. This is probably what would usually be done in hasty camps.

The broad arrow kitchen consists of three such trenches converging to one chimney (Pl. XXXII.), which may be built up to a height of 3½ to 5 ft. The trenches may be widened at their mouths to promote draught, and narrowed to 6 in. where they pass under the base of the chimney. They will last longer and draw better if plastered inside with clay.

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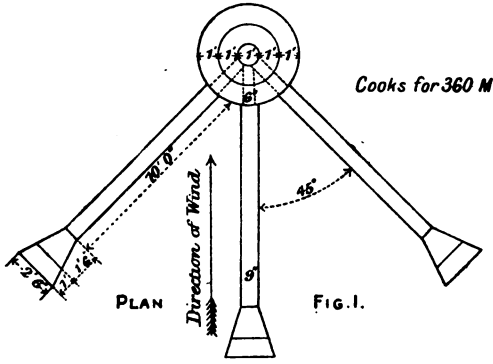
FIELD KITCHENS



Cooks for 360 Men.

PLAN FIG. I.

COVERED KITCHEN.

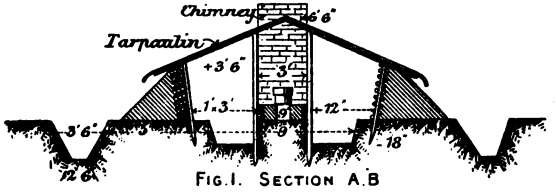


FIG. I. SECTION A.B

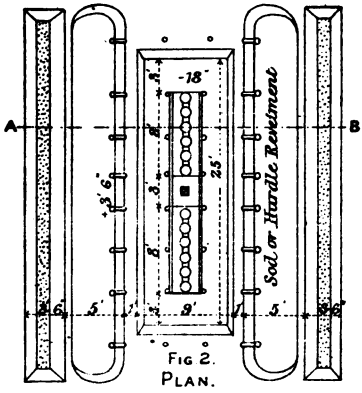


FIG 2.
PLAN.

Scale for Section 12 ft. - 1 inch
" " Plan 17 " - 1 "

A kitchen of this size will cook for 200 Men.

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FIELD OVENS.

Fig. 1

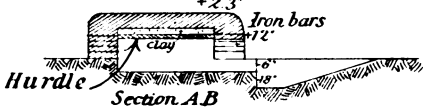
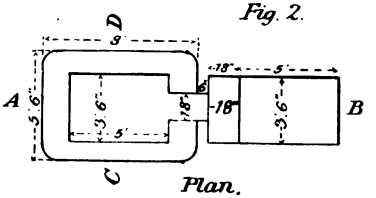


Fig. 2.



Figures 1 to 4
Oven without a flue.

Fig. 3.

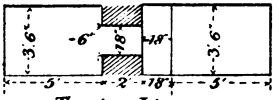


Fig. 4.

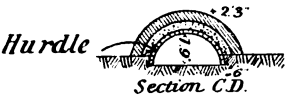


Fig. 5.

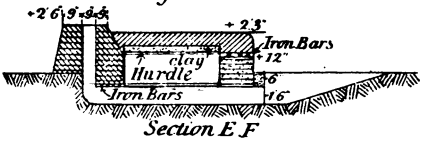
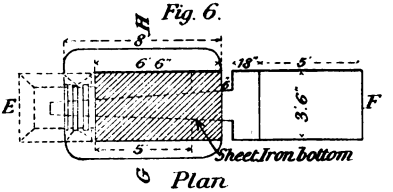


Fig. 6.



Figures 5 to 8
Oven with a flue.

Fig. 7

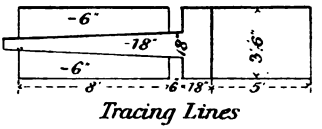
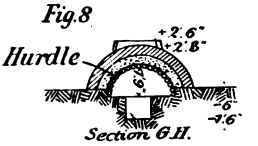


Fig. 8



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Other forms of kitchens are the *parallel* or *rectangular* type, in which each trench has a separate chimney and trenches are parallel to each other.

The *Gridiron* in which the trenches are parallel but have a common chimney.

Five men should make a broad arrow kitchen, as shown in Pl. XXXII., in four hours. Tools, etc., required: three picks, five spades, one bill-hook, one bundle pickets.

If troops are to be some time in a standing camp, covered kitchens should be provided. A suitable design is shown in Pl. XXXII. It will be noted that in this case the cooking trench is built *above* the ground level.

Field ovens.—The simplest form of a field oven consists of a hearth sunk below the ground surface, with an arch formed by a hurdle. (See Figs. 1—4, Plate XXXIII.). The two gable ends are formed with sods. The whole of the interior of the oven is well plastered with cow-dung and clay. The hurdle, well plastered on the outside with cow-dung and clay, so as to leave an arch when it burns away, is covered with earth from the excavation. The entrance to the oven is closed either by a hurdle plastered with clay, or simply by sods.

Instead of the hurdle-arch, sheet-iron may be substituted. An excellent oven can be made out of a cask in a clay soil.

One non-commissioned officer and seven men can make an oven in about four hours. *Tools*:—Pick-axes 2, bill-hook 1, gabion knives 3, mallet 1, rammer 1, shovels 4, also 5 ft. rod, tracing line, and a sod cutter (if available). This oven is specially suitable for making bread, and will bake for about 150 men at a time.

Figs. 5, 6, 7, 8, Pl. XXXIII., show an oven with a flue underneath an iron hearth. The oven is first heated

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by lighting a fire inside it, and this is afterwards raked out and pushed into the flue below to maintain the heat. It is a very useful oven for baking men's dinners. The service oven, Aldershot pattern, should be fixed up in this way.

Latrines.—Great care should be exercised in fixing the site of latrines that no filtration from them can reach the water supply. The direction of the prevailing wind must be considered, and latrines, urinals, refuse pits, etc., situated as far as possible from and, if possible, to leeward of the water supply and kitchens. Flies are great conveyors of disease.

Trenches must be narrow and deep to prevent the contents being blown about; about 2 ft. wide at the bottom and 3 ft. to 4 ft. deep.

The contents of latrine trenches should be covered with dry earth twice daily. Milk of lime (one part of quicklime to eight of water) should be freely used in latrines, urine pits (or tubs), refuse pits or slaughtering places, and on the ground round them.

All trenches should be carefully filled in by fatigue parties when no longer wanted. In standing camps, rough seats and screens should invariably be rigged up (Pl. XXXIV., Figs. 5 and 6), and lime or charcoal should be supplied as deodorizers.

Latrines should be constructed to seat, if possible, 10 per cent. of the troops, allowing one yard per man.

Separate latrines should be provided for natives.

Water supply.—Each man requires about half-a-gallon per diem for drinking, about one gallon for drinking and cooking, and not less than four gallons for drinking, cooking, and washing. Each horse requires six to 10 gallons daily for drinking and two gallons for cleaning. Each mule or ox requires practically the same for drinking. A sheep or pig will not want more than half to one gallon. (One gallon = 10 lbs.; and one cubic foot of water = $6\frac{1}{2}$ gallons). The foregoing quantities are the minimum which in each case will

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suffice. It is a good practical rule to allow in standing camps five gallons per man and 10 gallons per horse.

Horses drink about one and a half to two gallons at a time, and take about five minutes to drink.

The first troops to arrive on a halting ground at once mount sentries on all water likely to be required for use, with orders to prevent any form of pollution. These sentries are not withdrawn until permanent water guards are detailed.

An advanced party composed of Royal Engineers, if any are available, marks the water supply with flags as follows:—

White for drinking water.
Blue for watering places for animals.
Red for washing or bathing places.

Supply from streams.—If water is obtained from a stream, horses will be watered below the place where troops obtain their drinking water, but above bathing and washing places. Patrolling by mounted men will often be necessary for some distance up stream. Dead animals in war are a frequent cause of pollution. When the banks are high ramps to and from the stream will be made, and a hard bottom formed on the ramps to prevent the animals from sinking in. A barrier may be placed to prevent them from going out too far. The water should not be less than five inches or six inches deep where beasts are to drink.

Supply from springs, ponds, wells, etc.—If running water is not available, the supply must be very strictly protected, a rough barbed wire fence, if procurable, being run round it to keep animals out. Animals should, in this case, be watered by bucket or nose-bag; and washing should be allowed only at some distance from the water supply, empty biscuit tins, or other receptacles, being used to draw water for this purpose.

Similar precautions are often necessary with running water, if other bodies of troops are halted lower down the stream.

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Raising water from source.—Stagnant water, as in a pond, is apt to be contaminated by large numbers of animals going in to drink; and even in a stream, when many animals are drinking, those below get foul water. If possible, therefore, the water should be drawn from the source and run into drinking troughs; these are best made of canvas or of boards, but trenches lined with puddled clay answer the purpose.

The overflow from the troughs must be carried off with the surface drainage. The sites of the troughs should, if possible, be paved and drained for a width of 10 feet, and should be so arranged that the animals may move to and from them without confusion or crowding, arriving from one direction and leaving in another.

Each horse occupies, laterally, four feet; if possible, all the horses in a camp should be able to be watered in an hour.

If many animals have to be watered, and the frontage is small, hours should be laid down for each corps to water.

The most efficient service pump is the lift and force pump, weight 140 lbs., worked by two men. It can lift water from a depth of 20 feet to 28 feet, and force the water to a height of 60 feet from its former level, delivering 12 gallons per minute. Six men would be required to keep this rate up. Generally speaking, where pumps are used there will be engineers available, and it is not intended to deal in these notes with anything but a rough water supply taken direct from the source.

Pure drinking water.—As the health of a force depends largely on the purity of the water provided, everything possible must be done to ensure an ample supply of pure drinking water. Men must be prevented from drinking water that is not pure.

Water is best rendered safe for drinking purposes by being *boiled*, or by the use of *sterilising* filters, which must be kept clean, as otherwise they become dangerous

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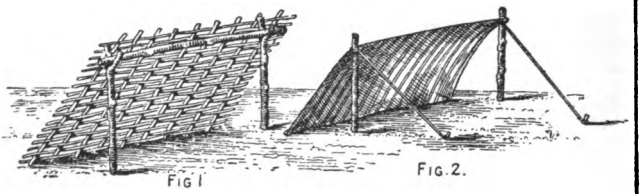

FIG 1 FIG.2.

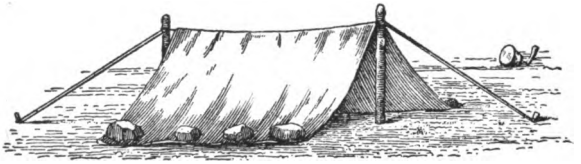

FIG.3.

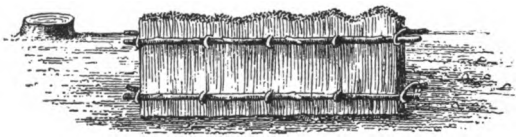

FIG.4

FIELD LATRINES

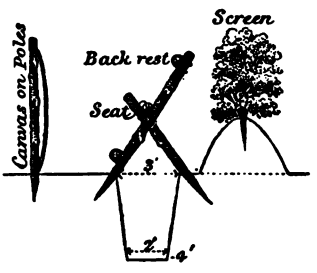

FIG.5

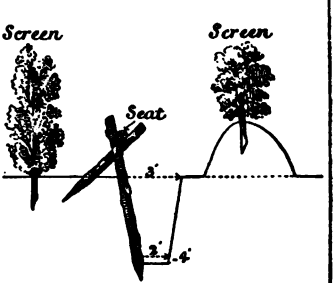

FIG.6.

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If boiled, water must be ærated by passing through a sieve, *e.g.*, a biscuit tin pierced with small holes.

A large Berkefeld filter will sterilise about 24 pints in ten minutes. The water must always be clarified first, as otherwise the filter becomes clogged. The water is forced through the filter by means of a small pump attached to the filter.

Whenever practicable, men should be specially detailed for the duty of supplying pure water. Vessels or tanks in which drinking water is stored are to be carefully covered, to keep out dust, etc., and they should be raised off the ground. The water cart with the unit will be the usual storage in the water supply of hasty camps.

Removal of minor impurities.—Often it is not possible to boil or filter the drinking water, and it may be fairly fit for drinking as it is.

Muddy water may be cleared by adding alum. Six grains of crystallized alum per gallon is sufficient. It should be added some hours before the water is required.

Water can be *softened* by the addition of lime water for drinking and carbonate of soda for washing purposes. The latter is unsuitable for drinking water as it gives an unpleasant taste.

Condy's fluid removes offensive smell from water and to some extent oxidises dissolved organic matter. It should be added until a faint tint remains permanent.

Old tea leaves put into drinking water help to precipitate organic matter.

Bivouacs.—"The worst billet is better than the best bivouac," nevertheless, troops constantly have to bivouac, and then every effort should be made to give them some shelter and protection from the weather, as their health and physical condition will always largely depend upon their comfort in camp.

Temporary shelters are easily rigged up in various ways, and are valuable even if they keep off the wind. Pl. XXXIV. suggests various methods which may be resorted to.

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Fig. 1 is a hurdle resting against a support. If hurdles are not available, branches may be substituted, thick ends uppermost.

Fig. 2 is simply a water-proof sheet or blanket secured by poles and string.

Fig. 3 is an improvised *tente d'abri* made out of two sheets laced together at the ridge. It will accommodate four men.

A *special service* blanket for *tentes d'abri* is an article of store.

Fig. 4 is a wall or screen of grass, straw or reeds, nipped between two sticks top and bottom, fastened at intervals.

In standing camps, regular huts may be constructed by the troops. The construction of these will depend entirely upon the materials available.

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EXAMINATION QUESTIONS.

CHAPTER I.

1.—What is the extreme effective range of field guns, and what considerations limit their range in practice?

2.—Describe briefly the projectiles used with field guns, and under what circumstances they are respectively used.

3.—Explain, with the aid of a diagram, what are the different kinds of artillery fire:—

(*a*) With reference to the horizontal plane.
(*b*) With reference to the vertical plane.

4.—Explain why "concealment" is so essential a feature of modern trenches.

5.—What are the average heights a man can conveniently fire over—

(*a*) Standing?
(*b*) Kneeling?
(*c*) Lying?

Which position gives the best cover when behind a parapet? How are these heights affected by the nature of the ground in front?

6.—Explain clearly why a trench need only have a bullet-proof parapet.

7.—Explain clearly how field guns would try to destroy the defenders of a fire trench.

8.—What protection will field fortification enable you to get from a howitzer common shell?

9.—Under what conditions is "burstback" of a high explosive shell to be feared?

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10.—What advantage have long range guns of position over field guns when employed in the attack of troops behind cover?

11.—A shrapnel bullet coming down at one in three just passes the top of a parapet 4 ft. 6 in. above the bottom of a trench. The trench is 3 ft. broad. Could the bullet strike the bottom of the trench supposing no traverses to be provided and fire to be very oblique?

If fire was frontal, could a man sit *facing* the parapet with safety?

12.—Discuss how the nature of earth affects the question of its penetration by rifle bullets.

13.—Explain why the proof thickness of a single brick or stone cannot be applied to walls of the same material. What thickness of walls is absolutely proof?

14.—Explain why field gun common shell is not much used against modern trenches.

15.—Why are walls so bad to defend against artillery fire?

CHAPTER II.

1.—What do you understand by "field defences," and what considerations chiefly determine their character?

2.—If fortifying any position, what are the principal objects to be kept in mind?

3.—How would you define and what do you consider the special requirement for:—

(*a*) An active defence?
(*b*) A passive defence?

4.—Explain the general disposition of troops for the defence of a position.

5.—Into what classes may entrenchments be divided?

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6.—What is the object of breaking up a line of trenches into groups with intervals?

7.—Why cannot trenches for civilised troops merely consist of a series of pits for one or two men each? What do you consider the minimum length of trench generally advisable?

8.—What considerations have usually to be taken into account when siting trenches:—

(*a*) On a convex slope?
(*b*) On a concave slope?
(*c*) On a glacis slope?

Consider each case on its pros and cons, and give your reasons.

9.—Mention the principal ways of gaining concealment for trenches.

10.—What points have to be attended to in making dummy trenches?

11.—Draw sections of trenches suitable for fire standing with no command and commands of one, two, three, and four feet respectively.

12.—Explain clearly the features that are common to all well designed trenches, and the reasons for them.

13.—What is the advantage of making an elbow rest?

14.—What would be principal defect in a trench cut out of hard soil 4 ft. deep and 1 ft. 9 in. wide?

15.—Explain how, if time permitted, you would improve the trenches in Question 11. Illustrate your answer with sketches.

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CHAPTER III.

1.—Explain the object of traversing a trench even when enemy's fire is not very oblique.

2.—Explain how to traverse trenches:—

(*a*) Of high command.
(*b*) Of low command.

Illustrate your answer with sketches, taking the case of trenches with 4 ft. 6 in. and no command.

3.—Explain the necessity of providing recesses on many occasions.

4.—Mention the principal points to attend to in designing a loophole.

5.—Draw hand sketches and give your reasons for the shape adopted of loopholes in the following cases:

(*a*) Fire trench. Sods and brushwood available. Range required 2,000 yards.
(*b*) As (*a*) but only 200 yards field of fire obtainable.
(*c*) As (*a*). Iron rails available.
(*d*) As (*b*). Bricks available and brushwood.
(*e*) As (*a*). Biscuit tins 2 ft. by 9 in. by 9 in. and brushwood available.

6.—Draw a hand sketch and explain the construction of a good sand-bag loophole.

7.—Draw a section of protected look-out, and explain the object of providing a look-out for a fire trench.

8.—What is the object of providing overhead cover? Draw a section of a trench with overhead cover in which the defenders can fire from under the cover.

9.—What are "cover trenches"? On what occasions would such trenches be necessary?

10.—Draw a hand sketch of a cover trench with overhead cover communicating with a fire trench.

11.—Explain the difficulties that crop up in many cases of arranging communications with the firing line

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to the rear. Draw sections of suitable trenches for this purpose.

12.—Compare the advantages and disadvantages of gun-pits and epaulments. Draw plans and sections of a gunpit and a gun epaulment for a field gun.

13.—Explain how trenches can be drained.

14.—Explain how to get cover quickly from a coal sack.

15.—What form of protection could be given a howitzer battery?

CHAPTER IV.

1.—Draw sections of an infantry parapet 4 ft. 6 in. command revetted:—

(*a*) With gabions of expanded metal, fascines, and sods.
(*b*) Sand-bags.
(*c*) Hurdles and sods.
(*d*) Continuous hurdlework and sand-bags.
(*e*) Blankets, stakes and sods.

Describe in each case the construction of the revetment.

2.—State the advantages and disadvantages of sods for revetments. How are they laid, and at what slope do they stand?

3.—Explain how you would work out an estimate of materials necessary for 100 yards of the parapet in Question 1. Give your results, and work out how many men would be required to do the revetting.

4.—Do fascines make a good revetment? State your reasons. What are fascines most useful for?

5.—What revetments do not require anchoring back? At what slope are good anchored revetments usually made? Will this be the final slope?

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6.—What sort of a revetment can men actually digging a fire trench make?

7.—Should the exterior slope of a fire trench parapet ever be revetted to save earth? Give your reasons.

8.—Draw a sketch of a parapet as in 1, revetted with planks and sods. Artillery fire is probable. The planks obtainable are 18 ft. long and 7 in. wide.

9.—Explain how casks could be used to revet parapet in Question 1.

10.—Describe how to revet the parapet with straw, stakes, and sods.

CHAPTER V.

1.—Explain the considerations to be taken into account in estimating tasks for digging and lengths of reliefs.

2.—When is it necessary to balance parapet and excavation? Design parapets and trenches of 2 ft. 6 in., 3 ft., 4 ft., 5 ft., and 6 ft. command.

3.—What is the object of providing shovellers to assist diggers?

4.—When is tracing works advisable?

5.—What works want profiling? How is this done?

6.—Work out suitable working parties for each relief to complete 100 yards of parapets in Question 2. State tasks, time required, materials and tools necessary. *Assume* the nature of the soil to be easy, medium or difficult, and the materials available for revetting to be brushwood, canvas, wire netting, sods, etc.

7.—Work out what cover a company of infantry can provide for itself in easy ground. Concealment is essential. At least 12 ins. command is required to see the ground in front:—

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(*a*) In one hour.
(*b*) In two hours.
(*c*) In four hours.

Assume.—A pick and shovel to every man.
Or a pick and shovel to every two men.
Or a pick and two shovels to every three men, etc.

Concealment and soil easy, medium, difficult, etc. Traverses at most convenient distances.

8.—What length of recessed trench 12 ins. command could 100 men make in four hours in easy soil? Draw a plan of a section of the trench between two traverses, showing how the recesses are fitted in. How many men could fire from this trench?

9.—Draw a section of overhead cover suitable for this trench, corrugated iron and earth being available. How much extra time do you think it would take to make it?

CHAPTER VI.

1.—Why is field of fire the first consideration of the defender?

2.—Explain why it is not necessary or advisable to cut down every tree in front of a position.

3.—Work out men and tools required to cut five acres of six year old brushwood, and say how many 50 lbs. bundles you would expect them to provide, and what carts would be necessary.

4.—Supposing the brushwood in Question 3 spoilt your field of fire and you only had men and time sufficient to clear half, what would you do?

5.—Why does the work in clearing a field of fire not end with cutting down trees?

6.—What party do you calculate could clear a quarter of the trees in a cherry orchard 250 yards by 400 yards? Trees about 5 ins. in diameter and 5 yds.

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apart. The cleared trees must be dragged to an abatis all along one of the long sides of the orchard.

7.—Why is it not advisable generally to fell isolated tall trees in front of a position? Does this apply to trees in the line of trenches? Give your reasons.

8.—How would you treat the following hedges:—

(*a*) A thick hedge parallel to the front and 300 yards in front of it?

(*b*) A thick hedge perpendicular to the front and in front?

(*c*) As (*b*) but inclined at 45 degrees?

(*d*) As (*c*) but leading to the rear of the position?

Give your reasons.

9.—What considerations have to be taken into account in determining whether houses in front of a position should be demolished?

10.—Describe how to deal with hollows in front of a firing line. When would you leave such hollows alone?

CHAPTER VII.

1.—What are the principal points to bear in mind when preparing a hedge for defence?

2.—What are the chief points to attend to in defence of a wall? Explain with a hand sketch how you would prepare for defence a wall 10 ft. high.

3.—How long does it take to make a loophole in a wall of ordinary thickness? What considerations govern the shape, distance apart, and position of loopholes in a wall?

4.—State how a railway cutting might be utilised in the defence of a position. What is necessary to make the cutting an efficient obstacle?

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5.—Explain fully how you would prepare for defence a line of wall 5 ft. high.

6.—Explain two ways by which fire can be directed at an enemy when he is close up to a defended wall and out of view of the defenders' main line. Illustrate your answer with sketches.

7.—Make a sketch showing how you would prepare the following hedge for defence:—Very thick holly hedge, 5 ft. high, ditches behind and in front, 2 ft. deep, and 2 ft. wide, edges of ditches about 3 ft. from middle of hedge. 3 ft. command is required to see the ground in front. Soil is moderately easy. Time available four hours.

How many men and what tools would be required to prepare 100 yards of above?

8.—What would you do in Question 7 if only two hours were available for work?

9.—What would you do in Question 7 if a second four hours relief was available?

10.—What would you do in Question 7 if no command was required to see the ground in front?

11.—Take Question 10 and apply conditions of Questions 8 and 9 to it.

12.—Draw a sketch of a railway embankment, 10 ft. above a level plain, and 20 ft. thick at the top. How would you propose to hold this:—

(*a*) With plenty of time available for defence?
(*b*) In a very hasty defence?

Comment on the disadvantages of holding such an embankment at all.

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CHAPTER VIII.

1.—Draw hand sketches of stockade work made out of:—

(*a*) Railway material.
(*b*) Brushwood, earth, and poles.
(*c*) Corrugated iron, shingle and poles.
(*d*) Blankets, coal, and stakes.

2.—What is a tambour useful for? Draw a plan of a small tambour.

3.—Explain how to loophole stockades in Question 1:—

(*a*) For long range fire.
(*b*) For fire at only 200 yards.

Give reasons for your ideas and shape of loopholes you would employ.

4.—When may stockades of timber logs often come in useful?

5.—In designing a stockade, what considerations affect the height of the bottom of the loophole above the ground outside and inside the stockade?

6.—Mention some instances in which blockhouses are usefully employed. What do you understand the term "blockhouse" to mean?

7.—State briefly the principal points to be borne in mind in designing a blockhouse.

8.—Design a blockhouse of wooden uprights, corrugated iron and shingle. Twenty loopholes are required, and fire effect is wanted equally all round. The roof is made of tarpaulin.

9.—Consider how you would defend any particular railway bridge, etc., by means of one, two, or more blockhouses. The problem can hardly be stated in words, but it will furnish excellent food for thought if applied in situ during an afternoon's walk.

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CHAPTER IX.

1.—What are the conditions desirable in a good obstacle? What uses do obstacles serve? In what kind of country would you consider them particularly valuable, and why?

2.—Describe *abatis* fully; its construction, suitable positions for it, time and men required to put it up, its special advantages, etc.

3.—Describe how you would entangle a strip of ground 10 yards wide, with stakes 3 ft. long, and wire (3,000 yards). What would be the length of the strip entangled, and how long would it take 20 men to complete it?

4.—Why must obstacles often be quite close to the defender's parapets in civilised warfare?

5.—Mention the chief advantages of wire as an obstacle.

6.—How would you make a felled hedge into an obstacle?

7.—What would be a favourable position for the formation of an inundation? On what will its length, breadth, and depth depend?

8.—Describe all the precautions which should accompany the construction of a street barricade.

9.—At what distance would you put obstacles from a parapet when fighting savages?

10.—Describe how a wire fence can be made into an efficient obstacle.

11.—Describe a strong form of obstacle that can be made with stakes 5 ft. long when plenty of wire and time is available.

12.—Work out the men, time, and wire required to make 400 yards length of the obstacle you propose in Questions 10 and 11.

13.—Describe how to make a simple automatic alarm in connection with a trip wire in the fence in Question 10. Make a sketch showing your ideas.

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14.—Describe how this trip wire could be made to ignite a flare. Illustrate your answer with a sketch.

15.—What is a fougasse? Draw a section of a small fougasse.

16.—What tools and appliances would you recommend a party carrying that had to surmount wire obstacles?

CHAPTER X.

1.—What are the advantages and disadvantages of occupying a village as a defensive post in the front line of a position?

2.—Explain how the work in preparing a village for defence is affected by the nature of the surrounding ground, and the shape of the village, and character of the houses in it.

3.—What are the main points to attend to in preparing a village for defence, and to what extent would you fortify it?

4.—How should the garrison for a village be reckoned and disposed?

5.—How is the garrison for the defence of a house reckoned? What kind of a house is best fitted for defence?

6.—Plenty of time being available, enumerate the successive steps to be taken in fortifying a house.

7.—How would you barricade the doors of a house, and what rules should be followed in loopholing the walls?

8.—Describe the construction and use of a machicoulis gallery?

9.—Describe generally the points to be borne in mind in organizing a village for defence as a detached post on the line of communications.

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10.—Discuss the advantages and disadvantages of woods in defensive positions.

11.—Explain how a very large wood should be prepared for hasty defence when—

(*a*) Front of wood is in front line of position. No field of fire obtainable till 30 yards from edge of the wood.

(*b*) As (*a*), but front edge of the wood will give a field of fire.

(*c*) When rear edge of wood is in front line of the position.

(*d*) When centre of the wood is in front line of the position.

Give reasons for what you propose.

12.—What would you do if plenty of time, tools, etc., were available in Question 11.

Give reasons for what you suggest.

N.B.—In most questions of practical fortification there are many sound answers to one question. Unless a candidate gives his reasons, it is difficult for an examiner to determine whether his answer is mere guess work, or the result of careful and well applied thought.

CHAPTER XI.

1.—What is a redoubt?

2.—Do you consider redoubts of much use in the front line of a position? Give your reasons.

3.—If redoubts are used in Question 2, what do you consider should be the dominant feature in their design?

4.—What considerations affect the trace of a redoubt?

5.—Design a redoubt for 200 men to meet the requirements of Question 2. 1 ft. 6 in. command is

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enough to see the ground all round. Fire from the front and flanks is equally important.

Draw sections of the front, rear, and flank faces, and the type of overhead cover employed.

Draw a plan of the work, showing general arrangement of shelters and traverses, etc. Artillery fire is roughly perpendicular to the front face. Work out the working parties, time, tasks, tools, materials, etc.

Briefly describe how you would lay out and organise the work.

6.—Why are high command redoubts often advisable in isolated situations? What are the general requirements of such a redoubt (*a*) when on a line of communication (*b*) as a support to an advanced screen?

7.—Design a redoubt as in Question 5, but with 6 ft. command. Attack may come from all sides.

8.—How are entrances to redoubts arranged?

9.—Why is it not usual to place artillery in redoubts?

10.—If an isolated post is too large to be contained in one redoubt, how do you arrange to give protection to men and animals in the post, when the necessary perimeter is large, and garrison is small?

11.—What would you do in Question 10, if only four hours were available for work?

N.B.—Both Questions 10 and 11 can only be properly answered by being applied for a particular body of troops to a particular site. A few general principles will apply to most situations.

12.—Explain how water supply is often a great difficulty for an isolated post, and how the difficulty may be overcome.

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CHAPTER XII.

1.—Think out what you would have done if another eight hours had been available for defence in the scheme worked out in Chapter XII.

2.—How would the scheme have been amended by you, if no second relief had been available?

3.—Work out approximately how much clearing and labour it would have involved to make Pendip Farm an advanced post backed up by the fire from the position.

It would take 200 men at least eight hours to raze the farm and outbuildings, even with plenty of explosives available.

The farm cannot be seen from the enemy's artillery position.

Which course would you recommend?

4.—As no map or plan will ever impress a piece of ground on your mind like the ground itself, take what you think a suitable piece of ground, and think out how you would prepare it for defence, in accordance with a given tactical idea, carefully limiting yourself to the practical requirements of the situation in men, time, and tools.

The assumptions necessary are all training your mind in practical field fortification which is only *applied common sense.*

CHAPTER XIII.

1.—Show (with rope) the difference between a reef knot, a thief knot, and a granny.

2.—Make a clove hitch on a spar, over the ends of which a rope cannot be slipped.

3.—Bend two ropes together of unequal sizes, and name the knot you use.

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4.—Lash a transom to a standard.

5.—Lash three spars together to form a gyn.

6.—Tie a rack-lashing.

7.—Lash two spars together to make a pair of sheers and attach the guy ropes, and show which way they will pull. Lash on a third spar to make a tripod trestle.

8.—Define the following terms used in bridging: *baulks*, *chesses*, *camber*, and *a bay*.

9.—Define *width in the clear*, and say what is the minimum width in the clear for the different arms in particular formation.

10.—State the precautions to be taken, and rules to be observed, to prevent confusion or accident at the passage of a military bridge.

11.—Under what conditions are trestle bridges applicable? What are their advantages? Give a hand-sketch of one frame for a trestle bridge, and name all the parts. Explain how to mark these spars for lashing.

12.—Enumerate the various kinds of frame bridges used in military operations, and the spans respectively bridged by them. In what cases are they used?

13.—Enumerate the spars required for single-lock bridge and describe the construction of one in detail.

14.—What points in a river are most suitable for the construction of a floating bridge, and what are least suitable?

15.—In a winding river where would you look for fords, and why?

16.—Describe a *flying bridge*, and the best kind of boat for it.

17.—Mention some of the points to be attended to in the construction of a boat bridge.

18.—Explain the construction of a raft bridge, and say what are its peculiar advantages and defects.

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19.—What are the various ways in which floating bridges can be constructed, and the advantages of each?

20.—What difference does a weight being concentrated or distributed make—

(*a*) To the road-bearers?
(*b*) To the transom?

Will a bridge with 10ft. bays, constructed to carry infantry in fours crowded, safely take wagons with 30 cwt. on the hind pair of wheels?

21.—If the bridge above quoted in Question 20 was a floating bridge, would the piers have enough buoyancy to take the wagons?

22.—What is the *available* buoyancy—

(*a*) Of a boat 28 ft. long and 5 ft. 6 in. wide, holding 40 unarmed men, with 12 in. freeboard?
(*b*) Of a 72 gallon cask?
(*c*) Of a 72 gallon cask without a head?
(*d*) Of a log of timber 33 ft. long and 15 in. diameter? The timber weighs 42 pounds per cubic foot.

23.—Determine a suitable span for a bridge to take infantry in file, the piers being made of boats as in 22 (*a*). Show that the pier fulfils the general conditions of floating piers, and describe how it is fitted up, making a rough sketch. Work out how many 6 in. mean diameter fir road-bearers are required for each bay.

24.—Work out on similar lines to Question 23, the piers being made of casks as in Question 22 (*b*). The dimensions of casks are given in the "Manual of Military Engineering."

25.—Work out on similar lines to Question 23, the piers being made of 36-gallon casks.

26.—What is the greatest number of men that ought to heave on a three-inch rope? How do you arrive

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at your result? Would you increase the number on a new rope?

27.—How could you lift a weight of 30 cwt. with 15 men? What stores in addition to the derrick and its guys, etc., would you want to do it?

28.—In water 10 ft. deep what minimum length of cable would you require to fasten to an anchor? Supposing the anchor would stand a pull of 1,000 pounds, what size should the cable be?

CHAPTER XIV.

1.—What is meant by *tamping* a charge?

2.—Enumerate the precautions to be observed in firing a charge of gun-cotton.

3.—Explain how you would attack a stockade with gun-cotton, or gunpowder.

4.—Describe the demolition of a masonry bridge with gun-cotton and gunpowder.

(*a*) In the case of a single arch bridge.
(*b*) In the case of a series of arches (1) with short and thick piers; (2) with high and thin piers.

5.—Describe how a line of railway may be temporarily disabled.

6.—How would you disable a line of telegraph without destroying it?

7.—What considerations have to be borne in mind when deciding on how to demolish a tunnel?

8.—What charge of gun-cotton is necessary to cut an iron girder of the following dimensions:—

Top flange, 21 in. by $1\frac{3}{4}$ in. Lattice work open web. Bottom flange 27 in. by $2\frac{1}{2}$ in.

Make a hand sketch showing charge arranged by slabs, fixed to the girder, and prepared for firing by hand.

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9.—In Question 4 work out the charges required and make rough sketches of their arrangement.

The span is 25 ft., width of roadway 25 ft., and the arch is 1 ft. 6 in. thick. The piers in 4 (*b*) (2) are 5 ft. thick.

10.—Describe how to cut a rail with gun-cotton in the form of slabs or primers.

11.—Describe how to make up, place, and fire a powder charge to blow down a stockade held by a savage foe.

12.—Describe three ways of cutting timber with gun-cotton.

13.—How would you cut down a hard wood tree 2 ft. 6 in. diameter with 1 oz. gun-cotton primers?

CHAPTER XV.

1.—What considerations affect—

(a) the length,
(*b*) the depth,
(*c*) the width,
of trenches in field kitchens?

Design a kitchen to cook for four companies of infantry.

2.—Describe the construction and method of using—

(*a*) An oven without a flue.
(*b*) An oven with a flue.

3.—Mention the principal points to be considered in siting and arranging latrines.

4.—A force of 500 men and 200 horses encamps for the night on the bank of a stream. Draw a rough sketch of the arrangements for water supply. Four water carts, holding 120 gallons each, accompany the force.

5.—Make a rough sketch of the arrangements for the same force when the supply is from a pond.

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6.—Supposing the water in Questions 4—5 to be polluted, what measures would you take to purify it?

7.—What water would the force require in a standing camp?

8.—How many service water troughs (33 ft. long each) would water the horses in ½ hour, the watering being done from one side only of the troughs?

9.—How long would a lift and force pump take to pump the drinking and cooking water required by the force into the water carts?

How many men would you allow for this fatigue?

10.—How long would it take five large filters as described on p. 231 to sterilize the drinking water required by this force? How many men would you allow to work the filters?

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The system of arrangement is open to criticism, but, be it remembered, a vast multitude of keen intellects is appealed to, each rightly considering his own special "service" to be the most important in the Army. The Editor would wish for nothing better than to gain the confidence of the Army, and would be grateful for any well-considered suggestions for adoption in future issues of what is hoped will prove a work of reference in military matters.

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For Full List of Official Military Books see page 55.

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